STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

Fuel Load Management Evaluation

Interim Report

L – 5

OROVILLE FACILITIES RELICENSING
FERC PROJECT NO. 2100

JUNE 2003

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REPORT SUMMARY

Relicensing stakeholders have expressed concern that historic land management and fire prevention activities within the study area have resulted in increased fuel load, which has led to an increased risk of destructive wildfires. An understanding of current and potential fuel load management issues and conditions within the study area would assist efforts to reduce the likelihood and/or severity of destructive wildfires.

The Fuel Load Evaluation Interim Report summarizes existing data on the current fuel load conditions in the study area, presents information on relevant fuel load reduction and management techniques, and summarizes the programs and policies of several land management and other local agencies. Based on this information, fuel load reduction measures are suggested that would be appropriate for generalized areas within the study area. The information presented in this report will not result in a fire management plan for the study area. However, the report may provide a framework or background information that would be useful to developing such a plan.

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ACRONYMS AND ABBREVIATIONS

ACEC	Areas of critical environmental concern
af	acre-feet
BLM	Bureau of Land Management
CARB	California Air Resources Board
CDF	California Department of Forestry and Fire Protection
CDZ	Community Defense Zone
cfs	cubic feet per second
dbh	Diameter at breast height
DEM	Digital Elevation Model
DFG	Department of Fish and Game
DFPZ	Defensible Fuel Profile Zone
DPR	Department of Parks and Recreation
DWR	Department of Water Resources
EBMUD	East Bay Municipal Utilities District
FERC	Federal Energy Regulatory Commission
FRAP	Fire Resource Assessment Program
FRSA	Feather River Service Area
FRZ	Fuel Reduction Zone
GIS	Geographic Information System
ICS	Incident Command System
LUWG	Land Use Working Group
maf	million-acre-feet
msl	mean sea level
MW	megawatts
NMED	New Mexico Environment Department
OWA	Oroville Wildlife Area
PM&E	Protection, mitigation, and enhancement
Project	FERC Project No. 2100
QLG	Quincy Library Group
RAM	Resource Area Manager
SBF	State Board of Forestry
SNEP	Sierra Nevada Ecosystem Program
SNFPA	Sierra Nevada Forest Plan Amendment
SP-L5	Fuel Load Management Study
SPLAT	Strategically Placed Area Treatment
SWP	State Water Project
UBC	Uniform Building Code
UCFPL	University of California, Forest Products Laboratory
UFL	University of Florida
UFLCES	University of Florida Cooperative Extension Service
USACE	U.S. Army Corps of Engineers
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
VMP	Vegetation Management Program

1.0 INTRODUCTION

1.1 PURPOSE

The purpose of the Fuel Load Management Evaluation Interim Report (Interim Report) is to present the information that has been gathered to date for SP-L5 (Fuel Load Management Evaluation) and to solicit feedback from the Land Use Working Group (LUWG), other working groups, and other interested parties.

SP-L5 is intended to summarize fuel load conditions, review relevant fuel load reduction and management techniques, summarize the programs and policies of relevant land management and other local agencies, and suggest some potential fuel load treatments for areas within the study area. The study area extends a quarter mile beyond the FERC Project No. 2100 (Project) boundary. The Project is managed by the California Department of Water Resources (DWR) for the purposes of water supply, flood management, and hydropower generation. The Federal Energy Regulatory Commission (FERC) license for the Project expires in February 2007. The relicensing process was initiated in June 2000, and the first public meeting for this Project was held in Oroville in the same month. The Interim Report has been developed in support of the Oroville Facilities relicensing process.

This Interim Report provides a status update of the current fuel load conditions, a review of relevant fuel load reduction and management techniques, summarizes the programs and policies of several land management and other local agencies, and suggests some fuel load reduction measures. Presentations of information contained in the Draft Interim Report were given to the LUWG on March 24 and April 21, 2003. Comments and suggestions made by the LUWG after those presentations are addressed to the extent possible in this report.

This report will also be reviewed by interested parties (agencies, Resource Area Managers [RAMs], the LUWG, and other Oroville Project study authors). Comments or suggestions received on this report will be incorporated into the Final Fuel Load Management Evaluation (Final Report), which will be submitted in September 2003. The Final Report will provide information that will be very useful for natural resource and land management entities near the Project, but it will not be a fire management plan.

This Interim Report is organized in the following manner:

- Section 1 provides the purpose and background information for the study.
- Section 2 describes study objectives.
- Section 3 describes study methods.
- Section 4 describes the fire history and fuel load conditions in the study area.

- Section 5 describes fuel load reduction techniques and management strategies, discusses their advantages and disadvantages, and evaluates their effectiveness.
- Section 6 describes fuel load management policies and plans being used by natural resource and land management entities in the Project region.
- Section 7 presents some general suggestions for fuel load reduction within the study area. Additional data useful to developing recommendations are discussed, including past fire ignitions and preliminary vegetation mapping. Some treatment methods are suggested that would be appropriate given vegetation, topography, and other constraints.
- Section 8 lists the references cited throughout this document.

1.2 BACKGROUND FOR STUDY SP-L5 (FUEL LOAD MANAGEMENT EVALUATION)

FERC does not require fuel load studies as part of the relicensing process. However, potentially destructive wildfire is an issue that land managers in the California foothills need to address. Relicensing stakeholders have expressed concern that historic land management and fire prevention activities within the study area have resulted in increased fuel load, which has led to an increased risk of destructive wildfires. An understanding of current and potential fuel load management issues and conditions within the study area would assist efforts to reduce the likelihood and/or severity of destructive wildfires. As mentioned in the preceding section, this Interim Report will not result in a fire management plan for the study area.

1.3 DESCRIPTION OF FACILITIES

The Oroville Facilities were developed as part of the State Water Project (SWP), a water storage and delivery system of reservoirs, aqueducts, power plants, and pumping plants. The main purpose of the SWP is to store and distribute water to supplement the needs of urban and agricultural water users in northern California, the San Francisco Bay area, the San Joaquin Valley, and southern California. The Oroville Facilities are also operated for flood management, power generation, to improve water quality in the Delta, provide recreation, and enhance fish and wildlife.

FERC Project No. 2100 encompasses 41,100 acres and includes Oroville Dam and Reservoir, three power plants (Hyatt Pumping-Generating Plant, Thermalito Diversion Dam Power Plant, and Thermalito Pumping-Generating Plant), Thermalito Diversion Dam, the Feather River Fish Hatchery and Fish Barrier Dam, Thermalito Power Canal, Oroville Wildlife Area (OWA), Thermalito Forebay and Forebay Dam, Thermalito Afterbay and Afterbay Dam, and transmission lines, as well as a number of recreational facilities. An overview of these facilities is provided on Figure 1.3-1. The Oroville Dam, along with two small saddle dams, impounds Lake Oroville, a 3.5-million-acre-feet (maf)

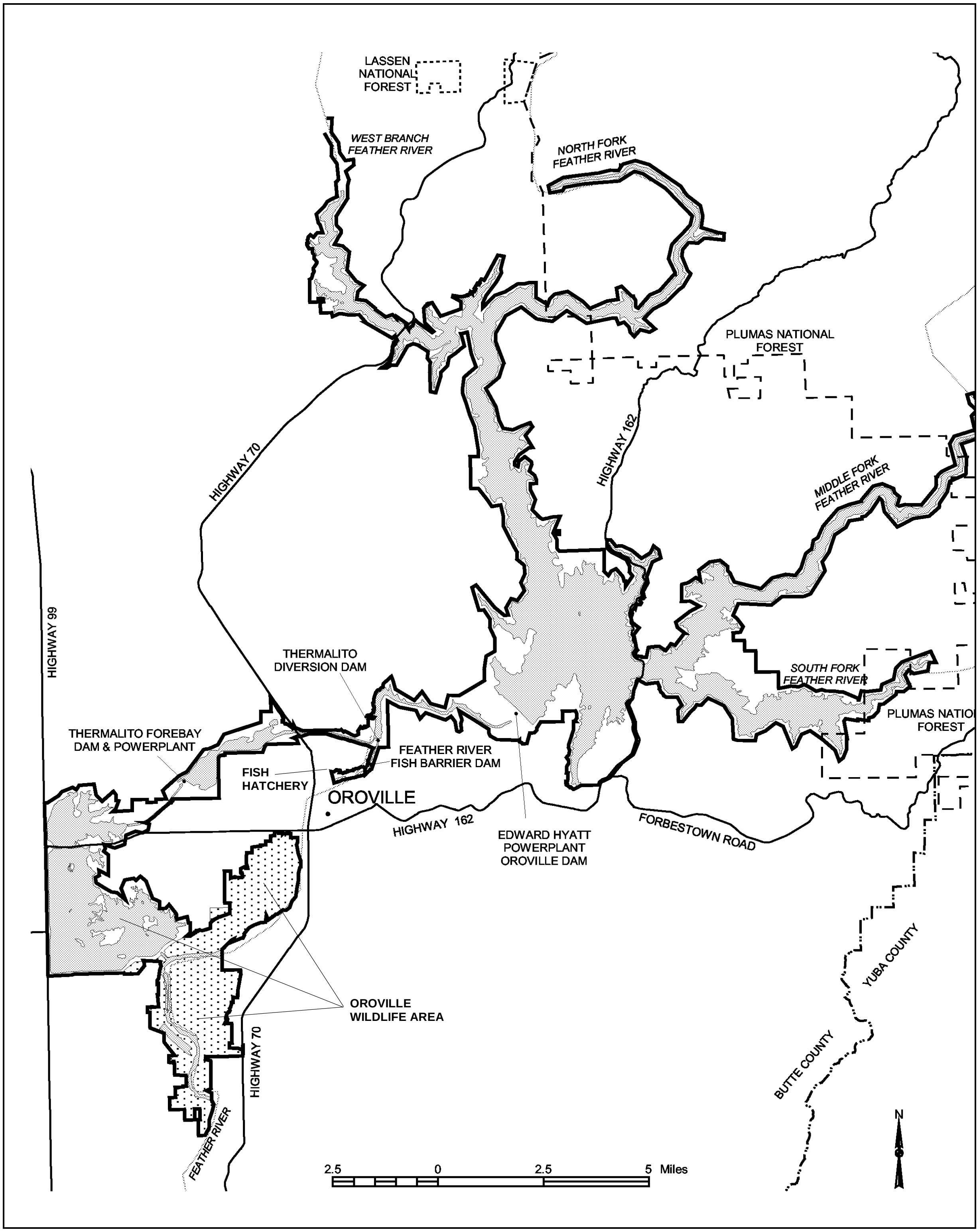

Figure 1.3-1. Oroville Facilities FERC project boundary.

capacity storage reservoir with a surface area of 15,810 acres at its normal maximum operating level.

The hydroelectric facilities have a combined licensed generating capacity of approximately 762 megawatts (MW). The Hyatt Pumping-Generating Plant is the largest of the three power plants with a capacity of 645 MW. Water from the six-unit underground power plant (three conventional generating and three pumping-generating units) is discharged through two tunnels into the Feather River just downstream of Oroville Dam. The plant has a generating and pumping flow capacity of 16,950 cfs and 5,610 cfs, respectively. Other generation facilities include the 3-MW Thermalito Diversion Dam Power Plant and the 114-MW Thermalito Pumping-Generating Plant.

Thermalito Diversion Dam, four miles downstream of the Oroville Dam creates a tail water pool for the Hyatt Pumping-Generating Plant and is used to divert water to the Thermalito Power Canal. The Thermalito Diversion Dam Power Plant is a 3-MW power plant located on the left abutment of the Diversion Dam. The power plant releases a maximum of 615 cubic feet per second (cfs) of water into the river.

The Power Canal is a 10,000-foot-long channel designed to convey generating flows of 16,900 cfs to the Thermalito Forebay and pump-back flows to the Hyatt Pumping-Generating Plant. The Thermalito Forebay is an off-stream regulating reservoir for the 114-MW Thermalito Pumping-Generating Plant. The Thermalito Pumping-Generating Plant is designed to operate in tandem with the Hyatt Pumping-Generating Plant and has generating and pump-back flow capacities of 17,400 cfs and 9,120 cfs, respectively. When in generating mode, the Thermalito Pumping-Generating Plant discharges into the Thermalito Afterbay, which is contained by a 42,000-foot-long earth-fill dam. The Afterbay is used to release water into the Feather River downstream of the Oroville Facilities, helps regulate the power system, provides storage for pump-back operations, and provides recreational opportunities. Several local irrigation districts receive water from the Afterbay.

The Feather River Fish Barrier Dam is downstream of the Thermalito Diversion Dam and immediately upstream of the Feather River Fish Hatchery. The flow over the dam maintains fish habitat in the low-flow channel of the Feather River between the dam and the Afterbay outlet, and provides attraction flow for the hatchery. The hatchery was intended to compensate for spawning grounds lost to returning salmon and steelhead trout from the construction of Oroville Dam. The hatchery can accommodate an average of 8,000 adult fish annually.

The Oroville Facilities support a wide variety of recreational opportunities. They include: boating (several types), fishing (several types), fully developed and primitive camping (including boat-in and floating sites), picnicking, swimming, horseback riding, hiking, off-road bicycle riding, wildlife watching, hunting, and visitor information sites with cultural and informational displays about the developed facilities and the natural environment. There are major recreation facilities at Loafer Creek, Bidwell Canyon, the Spillway, North and South Thermalito Forebay, and Lime Saddle. Lake Oroville has two full-service marinas, five car-top boat launch ramps, ten floating campsites, and seven dispersed floating toilets. There are also recreation facilities at the Visitor Center and the OWA.

The OWA comprises approximately 11,000-acres west of Oroville that is managed for wildlife habitat and recreational activities. It includes the Thermalito Afterbay and surrounding lands (approximately 6,000 acres) along with 5,000 acres adjoining the Feather River. The 5,000 acre area straddles 12 miles of the Feather River, which includes willow and cottonwood lined ponds, islands, and channels. Recreation areas include dispersed recreation (hunting, fishing, and bird watching), plus recreation at developed sites, including Monument Hill day use area, model airplane grounds, three boat launches on the Afterbay and two on the river, and two primitive camping areas. California Department of Fish and Game's (DFG) habitat enhancement program includes a wood duck nest-box program and dry land farming for nesting cover and improved wildlife forage. Limited gravel extraction also occurs in a number of locations.

1.4 CURRENT OPERATIONAL CONSTRAINTS

Operation of the Oroville Facilities varies seasonally, weekly and hourly, depending on hydrology and the objectives DWR is trying to meet. Typically, releases to the Feather River are managed to conserve water while meeting a variety of water delivery requirements, including flow, temperature, fisheries, recreation, diversion and water quality. Lake Oroville stores winter and spring runoff for release to the Feather River as necessary for project purposes. Meeting the water supply objectives of the SWP has always been the primary consideration for determining Oroville Facilities operation (within the regulatory constraints specified for flood control, in-stream fisheries, and downstream uses). Power production is scheduled within the boundaries specified by the water operations criteria noted above. Annual operations planning is conducted for multi-year carry over. The current methodology is to retain half of the Lake Oroville storage above a specific level for subsequent years. Currently, that level has been established at 1,000,000 acre-feet (af); however, this does not limit draw down of the reservoir below that level. If hydrology is drier than expected or requirements greater than expected, additional water would be released from Lake Oroville. The operations plan is updated regularly to reflect changes in hydrology and downstream operations. Typically, Lake Oroville is filled to its maximum annual level of up to 900 feet above mean sea level (msl) in June and then can be lowered as necessary to meet downstream requirements, to its minimum level in December or January. During drier years, the lake may be drawn down more and may not fill to the desired levels the following spring. Project operations are directly constrained by downstream operational constraints and flood management criteria as described below.

1.4.1 Downstream Operation

An August 1983 agreement between DWR and DFG entitled, "Agreement Concerning the Operation of the Oroville Division of the State Water Project for Management of Fish & Wildlife," sets criteria and objectives for flow and temperatures in the low flow channel and the reach of the Feather River between Thermalito Afterbay and Verona. This agreement: (1) establishes minimum flows between Thermalito Afterbay Outlet and

Verona which vary by water year type; (2) requires flow changes under 2,500 cfs to be reduced by no more than 200 cfs during any 24-hour period, except for flood management, failures, etc.; (3) requires flow stability during the peak of the fall-run Chinook spawning season; and (4) sets an objective of suitable temperature conditions during the fall months for salmon and during the later spring/summer for shad and striped bass.

1.4.1.1 Instream Flow Requirements

The Oroville Facilities are operated to meet minimum flows in the Lower Feather River as established by the 1983 agreement (see above). The agreement specifies that Oroville Facilities release a minimum of 600 cfs into the Feather River from the Thermalito Diversion Dam for fisheries purposes. This is the total volume of flows from the diversion dam outlet, diversion dam power plant, and the Feather River Fish Hatchery pipeline.

Generally, the instream flow requirements below Thermalito Afterbay are 1,700 cfs from October through March, and 1,000 cfs from April through September. However, if runoff for the previous April through July period is less than 1,942,000 af (i.e., the 1911-1960 mean unimpaired runoff near Oroville), the minimum flow can be reduced to 1,200 cfs from October to February, and 1,000 cfs for March. A maximum flow of 2,500 cfs is maintained from October 15 through November 30 to prevent spawning in overbank areas that might become de-watered.

1.4.1.2 Temperature Requirements

The Diversion Pool provides the water supply for the Feather River Fish Hatchery. The hatchery objectives are 52°F for September, 51°F for October and November, 55°F for December through March, 51°F for April through May 15, 55°F for last half of May, 56°F for June 1-15, 60°F for June 16 through August 15, and 58°F for August 16-31. A temperature range of plus or minus 4°F is allowed for objectives, April through November.

There are several temperature objectives for the Feather River downstream of the Afterbay Outlet. During the fall months, after September 15, the temperatures must be suitable for fall-run Chinook. From May through August, they must be suitable for shad, striped bass, and other warmwater fish.

The National Marine Fisheries Service has also established an explicit criterion for steelhead trout and spring-run Chinook salmon. Memorialized in a biological opinion on the effects of the Central Valley Project and SWP on Central Valley spring-run Chinook and steelhead as a reasonable and prudent measure; DWR is required to control water temperature at Feather River mile 61.6 (Robinson’s Riffle in the low-flow channel) from June 1 through September 30. This measure requires water temperatures less than or equal to 65°F on a daily average. The requirement is not intended to preclude pump-back operations at the Oroville Facilities needed to assist the State of California with supplying energy during periods when the California ISO anticipates a Stage 2 or higher alert.

The hatchery and river water temperature objectives sometimes conflict with temperatures desired by agricultural diverters. Under existing agreements, DWR provides water for the Feather River Service Area (FRSA) contractors. The contractors claim a need for warmer water during spring and summer for rice germination and growth (i.e., 65°F from approximately April through mid May, and 59°F during the remainder of the growing season). There is no obligation for DWR to meet the rice water temperature goals. However, to the extent practical, DWR does use its operational flexibility to accommodate the FRSA contractor's temperature goals.

1.4.1.3 Water Diversions

Monthly irrigation diversions of up to 190,000 (July 2002) af are made from the Thermalito Complex during the May through August irrigation season. Total annual entitlement of the Butte and Sutter County agricultural users is approximately 1 maf. After meeting these local demands, flows into the lower Feather River continue into the Sacramento River and into the Sacramento-San Joaquin Delta. In the northwestern portion of the Delta, water is pumped into the North Bay Aqueduct. In the south Delta, water is diverted into Clifton Court Forebay where the water is stored until it is pumped into the California Aqueduct.

1.4.1.4 Water Quality

Flows through the Delta are maintained to meet Bay-Delta water quality standards arising from DWR's water rights permits. These standards are designed to meet several water quality objectives such as salinity, Delta outflow, river flows, and export limits. The purpose of these objectives is to attain the highest water quality, which is reasonable, considering all demands being made on the Bay-Delta waters. In particular, they protect a wide range of fish and wildlife including Chinook salmon, Delta smelt, striped bass, and the habitat of estuarine-dependent species.

1.4.2 Flood Management

The Oroville Facilities are an integral component of the flood management system for the Sacramento Valley. During the wintertime, the Oroville Facilities are operated under flood control requirements specified by the U.S. Army Corps of Engineers (USACE). Under these requirements, Lake Oroville is operated to maintain up to 750,000 af of storage space to allow for the capture of significant inflows. Flood control releases are based on the release schedule in the flood control diagram or the emergency spillway release diagram prepared by the USACE, whichever requires the greater release. Decisions regarding such releases are made in consultation with the USACE.

The flood control requirements are designed for multiple use of reservoir space. During times when flood management space is not required to accomplish flood management objectives, the reservoir space can be used for storing water. From October through

March, the maximum allowable storage limit (point at which specific flood release would have to be made) varies from about 2.8 to 3.2 maf to ensure adequate space in Lake Oroville to handle flood flows. The actual encroachment demarcation is based on a wetness index, computed from accumulated basin precipitation. This allows higher levels in the reservoir when the prevailing hydrology is dry while maintaining adequate flood protection. When the wetness index is high in the basin (i.e., wetness in the watershed above Lake Oroville), the flood management space required is at its greatest amount to provide the necessary flood protection. From April through June, the maximum allowable storage limit is increased as the flooding potential decreases, which allows capture of the higher spring flows for use later in the year. During September, the maximum allowable storage decreases again to prepare for the next flood season. During flood events, actual storage may encroach into the flood reservation zone to prevent or minimize downstream flooding along the Feather River.

2.0 STUDY OBJECTIVES

The objectives of this study are to:

- Provide the reader with background information regarding fuel loading and fuel load management issues;
- Characterize the general fuel load conditions in the study area;
- Discuss and evaluate the efficiency level and/or drawbacks of various fuel load management and reduction methods;
- Communicate relevant information to other work groups for their use and evaluation;
- Summarize the analyses of other work groups with regard to the effects that various fuel load management strategies and techniques might have on other resources; and
- Suggest preferred fuel-load management and reduction techniques.

3.0 STUDY METHODS

Task 1: Assessment of Current Fuel Loads within the Study Area

A literature and data review of appropriate study area-related land management and fire control data was conducted. California Department of Forestry and Fire Protection (CDF) personnel, websites, geographic information system (GIS) databases, and published documents are the primary sources of data. The California Fire Plan (CDF 1996) and the CDF Butte Unit's Fire Management Plan (CDF 2002a) were reviewed. The Fuel Hazard Ranking model that CDF developed for the Butte Unit was also reviewed to evaluate the fire hazard for the study area. The information gathered in this task is included in Section 4.

Task 2: Identify Fuel Load Reduction Techniques, Strategies, Management Policies, and Programs

This task involved conducting literature reviews and interviews. CDF staff were consulted regarding fuel treatment and management techniques. The California Fire Plan and other CDF information regarding various fuel management and treatment techniques were consulted. In addition, land management and fire control officials from the U.S. Forest Service (USFS) and California Department of Parks and Recreation (DPR) were interviewed regarding ongoing fuel reduction programs. The DPR Wildfire Management Planning Guidelines and Policy (DPR 2002) and the Butte County General Plan (1996) were reviewed. Personnel at other entities such as the Bureau of Land Management (BLM), DFG, and the City of Oroville were contacted. Section 5 identifies fuel load reduction techniques and management strategies, discusses their advantages and disadvantages, and summarizes what is known about the overall effectiveness of the methods. Section 6 describes the fuel load management policies and plans used by agencies in the Project region.

Task 3: Suggested Fuel Load Reduction Measures

This task used the information gathered in the previous tasks to suggest some general fuel load reduction measures for the study area. Fuel reduction measures are suggested based on the review of various techniques, programs and policies currently being used by local agencies, as well as general vegetation types within the study area. This task does not entail a fire reduction or management plan, but contains data and suggestions that could be expanded to develop such a plan. The suggested measures developed in this task could be used to develop protection, mitigation, and enhancement (PM&E) measures.

4.0 FUEL LOAD ISSUES AND FUEL LOAD CONDITIONS IN THE STUDY AREA

This section is composed of two subsections. The first subsection (4.1) provides general background information on the ecological role of fire and the effects of activities in the last century on forests as they relate to fuel load conditions. The second subsection (4.2) describes the fire history in the Project region and characterizes the general fuel load conditions in the study area.

4.1 THE ROLE OF FIRE AND HISTORY OF FIRE MANAGEMENT IN THE SIERRA NEVADA

4.1.1 The Ecological Role of Fire and Presettlement Conditions

Fire is a natural evolutionary force that has influenced Sierran ecosystems for millennia, influencing biodiversity, plant reproduction, vegetation development, insect outbreak and disease cycles, wildlife habitat relationships, soil functions and nutrient cycling, gene flow, selection, and, ultimately, sustainability [Sierra Nevada Ecosystem Program (SNEP) 1996].

The various forest habitats and communities in the Sierra Nevada today were created by the influence of fire over thousands of years (Barbour et al. 1987). California has a Mediterranean climate with cool, wet winters and warm, dry summers, which provides suitable weather and dry fuels for burning. Lightning during thunderstorms provides a natural ignition source (SNEP 1996). Native Americans who inhabited the region were also known to frequently ignite forest fires for numerous cultural purposes (SNEP 1996). The Native Americans started low-burning fires to control understory growth from competing with desirable species such as oaks for acorn production, which was a main staple of their diet, for plants favorable for basket weaving, to clear brush around their homes, and to enhance habitat for game species (McKelvey et al. 1996; Skinner and Chang 1996). In the absence of suppression efforts, fires would spread until weather conditions or fuels were no longer suitable (SNEP 1996).

Much of the vegetation in the Sierra Nevada exhibits traits that allow survival and reproduction in this environment of regular fire. Prior to the mid-1800s many plant communities experienced fire at least once, and often a number of times, during the life spans of the dominant species (McKelvey et al. 1996). Chaparral and mixed conifer communities are especially adapted to regular and frequent fires and depend on fire for their reproduction and as a means of competing with other biota (SNEP 1996). Fire-scar records in tree rings have shown variable fire-return intervals in presettlement times, with median values consistently less than 20 years for the foothill, ponderosa pine, and mixed conifer zones of the Sierra Nevada (SNEP 1996) (Table 4.1-1). Intervals between fires vary depending climate, elevation, topography, vegetation, soil chemistry, and human cultural practices (Skinner and Chang 1996).

The variable nature of presettlement fire helped create diverse landscapes and variable forest conditions (SNEP 1996). In many areas, frequent surface fires are thought to have minimized fuel accumulation, keeping understories relatively free of small trees and other vegetation that could form fuel ladders, which allow fire to move into the main canopy. The effects of frequent surface fires would largely explain reports and photographs of early Euro-American settlers who describe Sierran forests as typically "open and park-like" (SNEP 1996). However, there are also many reports from the same period that describe the forests as dark, dense, and impenetrable (SNEP 1996). From the differing reports, it is likely that Sierran forests were a mix of open forests and impenetrable stands of brush and young trees (SNEP 1996).

Table 4.1-1. Historical and contemporary fire-return intervals.

Forest Type	Fire-Return Interval (Years)	
	20th Century	**Pre-1900**
Red fir	1,644	26
Mixed conifer-fir	644	12
Mixed conifer-pine	185	15
Ponderosa pine	192	11
Blue oak	78	8

Source: SNEP 1996

The way that fire affects the landscape is a largely a result of its frequency (return-interval), spatial extent (size), and its magnitude. The magnitude of a fire refers to both its intensity and severity. Intensity is a technical term used to describe the amount of energy released from a fire and may or may not be directly related to fire effects. Severity is related to the change in the ecosystem caused by the fire. Fires that burn only surface fuels (i.e., surface fires), and in which most of the woody vegetation survives, are usually considered low-severity fires. Fires that kill most small trees, with only some of the subcanopy trees killed or damaged and occasionally overstory trees killed, are considered moderate-severity fires. Fires that kill large trees over more than a few acres by burning their crowns (i.e., crown fires) are usually considered high-severity fires (Skinner and Chang 1996).

Most presettlement fires were low to moderate severity, with only a few patches of high severity. High-severity fires likely occurred occasionally but were probably much less common than today. These conclusions are based on research of fuel dynamics, forest age structure analysis, written accounts of early fires, and observations of modern fires (SNEP 1996). More frequent fire-return intervals reduced the horizontal and vertical biomass in the forest, which regulated the severity of the fire at a low or moderate level and helped prevent crown fires (McKelvey et al. 1996; Skinner and Chang 1996). As a result, the landscape consisted of a mosaic of forest patches in a variety of stand ages, which is more likely to function as a diverse ecosystem than an even-aged stand generated by a severe and widespread fire (Skinner and Chang 1996).

Another difference between presettlement and current fire patterns is the location of the fires. The presettlement return interval for fires in the foothills (i.e., blue oak forest) through the upper mixed conifer zone did not differ much (See Table 4.1-1). However, recent fire patterns show a decrease in fire frequency with an increase in elevation. The distribution of fires in the 20th century is closely associated with drought conditions and probably is due to effective suppression of low- to moderate-intensity fires. Before settlement, 10 times as much area in the foothills burned when compared with the 20th century, and 60 times as much burned in the red fir zone (McKelvey et al. 1996).

Periodic fires performed a number of ecological functions. Fire damaged or killed some plants, creating conditions for regeneration or vegetation succession (SNEP 1996). Fire influenced many processes in the soil and forest floor by consuming organic matter and inducing thermal and chemical changes. Nutrient cycling is also affected by fire. Periodic fires removed biomass from small shrubs and trees, which contribute to surface and ladder fuels and promoted large tree growth. Periodic fires also generate mosaics of vegetation in different successional stages across the landscape (SNEP 1996).

4.1.2 Euro-American Settlement: Logging and Fire Suppression

Euro-American settlement following the discovery of gold in California in the mid-1800s initiated profound changes in the role of fire in Sierra Nevada ecosystems (SNEP 1996). Many factors have influenced changes in fire patterns in the Sierras over the last century (e.g., population decline among native peoples, grazing, mining, logging, recreation, settlement, fire management) (McKelvey et al. 1996; Skinner and Chang 1996). However, logging and fire suppression are probably the two most significant activities that have influenced forest fuels due to the intensity and widespread distribution of these activities.

Logging was initially undertaken to supply mines and later to support the growing population of the new state. Timber volumes harvested in the Sierras continued to increase into the 20th century, reaching a peak in the 1970s and 1980s (SNEP 1996). Typically, loggers harvested large trees and fire-resistant species, and these were replaced by more fire-susceptible smaller trees. This pattern of biomass removal contrasted markedly with that of presettlement surface fires, which tended to kill small trees and leave many large trees to survive (SNEP 1996). Logging also tends to result in large quantities of debris left on the ground, which contributes to fuel loading and to severe fires (McKelvey et al. 1996). The forest management practices used in the 20th century have significantly contributed to a younger, denser, more homogenous forest structure (McKelvey et al. 1996).

The settlement of the Sierras also resulted in an emphasis to extinguish any and all fires to protect property and homes. After a series of disastrous fires in 1910 and period of trial and debate about the merits of "light burning" as a management tool in forests and rangelands, intentional broadcast burning was repudiated, and aggressive fire control became firmly established as State and federal policy (SNEP 1996). Combined with the loss of ignitions by Native Americans, fire suppression activities significantly reduced the area burned by wildfires during the last century (SNEP 1996). Although fire suppression efforts have varied throughout the landscape, depending on location, severity, accessibility, cost, and vegetation type, the policy emphasized keeping wildland fires as small and inexpensive as possible (Husari and McKelvey 1996).

The virtual exclusion of widespread low- to moderate-severity fires has affected the structure and composition of most Sierra Nevada vegetation, especially in low- to middle-elevation forests. Conifer stands generally have become denser and consist of mainly small and medium size classes of shade-tolerate and fire-sensitive tree species. Vertical fuels have become more continuous, contributing to higher risk of canopy fires (Figure 4.1-1). In combination with the removal of large trees for timber, conditions have promoted the establishment of dense, young forests. As a result, stands in many areas have experienced increased mortality recently from the cumulative effects of competition (primarily for water and light), drought, insects, disease, and in some cases air pollution (SNEP 1996).

Today's forest conditions more readily support severe fires due to the structure of the forest vegetation and the accumulation of fuel (McKelvey et al. 1996). The increased

Source: Quincy Library Group, Hungry Creek Fuel Project

Figure 4.1-1. Example of vertical (or ladder) fuels, which may allow fires to spread from ground to canopy.

density of young trees together with increased fuels from fire suppression and tree mortality have created conditions favorable to more intense and severe fires. The understory vegetation is left to flourish, providing a connection between ground fuels and the canopy trees, in addition to adding fuel to the forest floor. The denser forests have intertwined canopies, allowing for fire to spread easily from one tree to the next in the canopy. Moreover, severe fires are more likely to be large in size because they are more difficult to suppress (SNEP 1996). After a widespread and severe fire, large areas of even-aged stands regenerate, decreasing the variability of the landscape (McKelvey et al. 1996).

Human settlement in the Sierra Nevada is continuing, and the populations of many communities have been rapidly increasing in the last few decades (SNEP 1996). The propensity of people to build homes in forested areas without mitigating fire hazards and risks has increasingly placed homes and other valuable property at risk to loss to severe wildfires (SNEP 1996). Although fire fighting technologies have improved and many resources are dedicated to protecting people, structures, and other resources, many hundreds of homes have been destroyed by wildfires in the Sierra over the past few decades (SNEP 1996).

In summary, three major fire-related "problems" have been identified in the Sierra Nevada:

(1) Too much high-severity fire and high probability for future high-severity fires if fuel load condition trends continue;

(2) Too little low- to moderate-severity fire, with a variety of ecological changes attributed at least in part to this deficiency; and

(3) A large number of homes and other structures at risk due to both existing and continued rural development in areas with extreme fire hazards that are not reduced to acceptable levels (SNEP 1996).

These problems can be translated into three closely related and complementary broad goals for fire management in the Sierra Nevada:

(1) Reduce substantially the area and average size of acres burned by large, high-severity wildfires;

(2) Restore more of the ecosystem functions of frequent low- to moderate- severity fire; and

(3) Encourage a more rational approach for the intermix of homes and wildland vegetation with high fire-risk hazard (SNEP 1996).

Understanding the ecology and history of fire in the region will assist in management decisions and developing successful fuel load management strategies. The following management practices have been recommended by fire scientists to assist in restoring and/or maintaining forest ecosystem functions (McKelvey et al. 1996):

- Restore ecosystem functions that are characteristic of frequent and less severe fires.
- Cooperate with landowners for fire prevention where development has encroached upon fire hazard areas.
- Thin smaller diameter trees or conduct biomass removals to shape a more open-structured forest.
- Dispose of slash from tree removal to control the severity of the fire.
- Apply fuel treatments periodically to maintain the low fuel load.
- Carefully consider locations for fuel load management effectiveness and economic viability.
- Use a landscape-level strategy.
- Use treatments that are successful in reducing the hazard but are also compatible with ecosystem sustainability.
- Remove biomass at a rate that exceeds production.
- Choose treatment strategies based on historic patterns of fire risk.
- Use prescribed burning at a landscape level for fuel reduction and restoration of ecosystem processes, but not as a sole treatment method.
- Modify the current fire suppression strategy; use less than full control strategies that remain economical but do not completely suppress the fire and allow it to burn under control.

4.2 EXISTING FUEL LOAD CONDITIONS WITHIN THE STUDY AREA

The descriptions of the fire history and existing fuel load conditions within the study area are based on data provided by CDF. To develop fire management plans, CDF maintains detailed and up-to-date GIS databases for fire history, ignition locations, fuel type, and other information to allow for comprehensive analysis of fire hazards, assets at risk, and level of service. Section 4.2.1 summarizes the fire history in the Project region. Using this information and other data, CDF has developed a fuel hazard model, described in Section 4.2.2. Model results specific to the study area are presented in Section 4.2.3.

4.2.1 Fire History in the Project Region

CDF maintains a database of where fires have occurred in the past; the database includes records of fires from the early 1900s to present. CDF typically maps timber fires if they are 10 acres or greater, brush fires 50 acres or greater, and grassland fires

300 acres or greater. Figure 4.2-1 shows the extent of significant-sized fires within the study area region. Prior to 2000, CDF generally only recorded fires within the State Responsibility Area (east of Highway 70 in the study area). Since 2000, CDF has included fires in the Local Responsibility Area (generally west of Highway 70 in the study area). Therefore, the fire perimeter data for the OWA and other areas west of Highway 70 are incomplete prior to 2000. However, a couple of fires in 1990 are shown.

In recent years (since 1990), there have been large fires in the northern portion of Lake Oroville (e.g., "Bloomer" in 1999, "Concow" in 2000, "Poe" in 2001), a few fires in the Middle Fork ("Bean Creek" in 1999 and "Union" in 1999 and 2002), and a fire in the Loafer Creek Area ("South" in 1999). Other recent fires have occurred in the Oroville Wildlife Area ("Wild" in 1990 and "Larkin" in 2001) and near the Thermalito Afterbay ("Nelson" in 1993 and "Table" in 1994). Table 4.2-1 lists the recent fires that have at least partially occurred within the study area, the total acreage burned, and the cause of the fire.

4.2.2 California Department of Forestry and Fire Protection, Fuel Hazard Model

CDF has developed a fuel assessment methodology to describe current fuel load conditions and rank fuel hazard situations to assist prefire planners and Fire Safe councils target critical areas for fuel treatment. The fuel ranking methodology assigns ranks based on current flammability of particular fuel types, slope, average weather conditions, ladder fuels, and crown density. The model uses GIS technology to build and analyze the data.

In the study area, as in the surrounding Sierra Nevada ecosystem, grass, brush, and timber are the most common fuel types. Each fuel has its own burning characteristics based on several factors, including moisture content, volume, live to dead vegetation ratio, size, structure, and inherent species characteristics such as volatility. Fuel load is measured in tons per acre. For example, grass is considered a light fuel with a volume of approximately 3/4 tons per acre; thick brush is considered a heavy fuel, with a volume of over 21 tons per acre.

The first step in developing the fuel hazard model is to determine fuel types. The fuel types are initially determined from aerial photograph interpretation and validated where necessary with on-the-ground assessments. The mapping unit is 450-acre blocks, based on dividing a 7.5-minute topographic quadrangle into 81 sections (a 9-by 9-grid), called Quad 81st. Each Quad 81st is then categorized into one of 13 fuel models based on their burn characteristics. These 13 fuel models are based on the Fire Behavior Prediction System developed by USFS. The models take into account vegetation type and other fuel characteristics.

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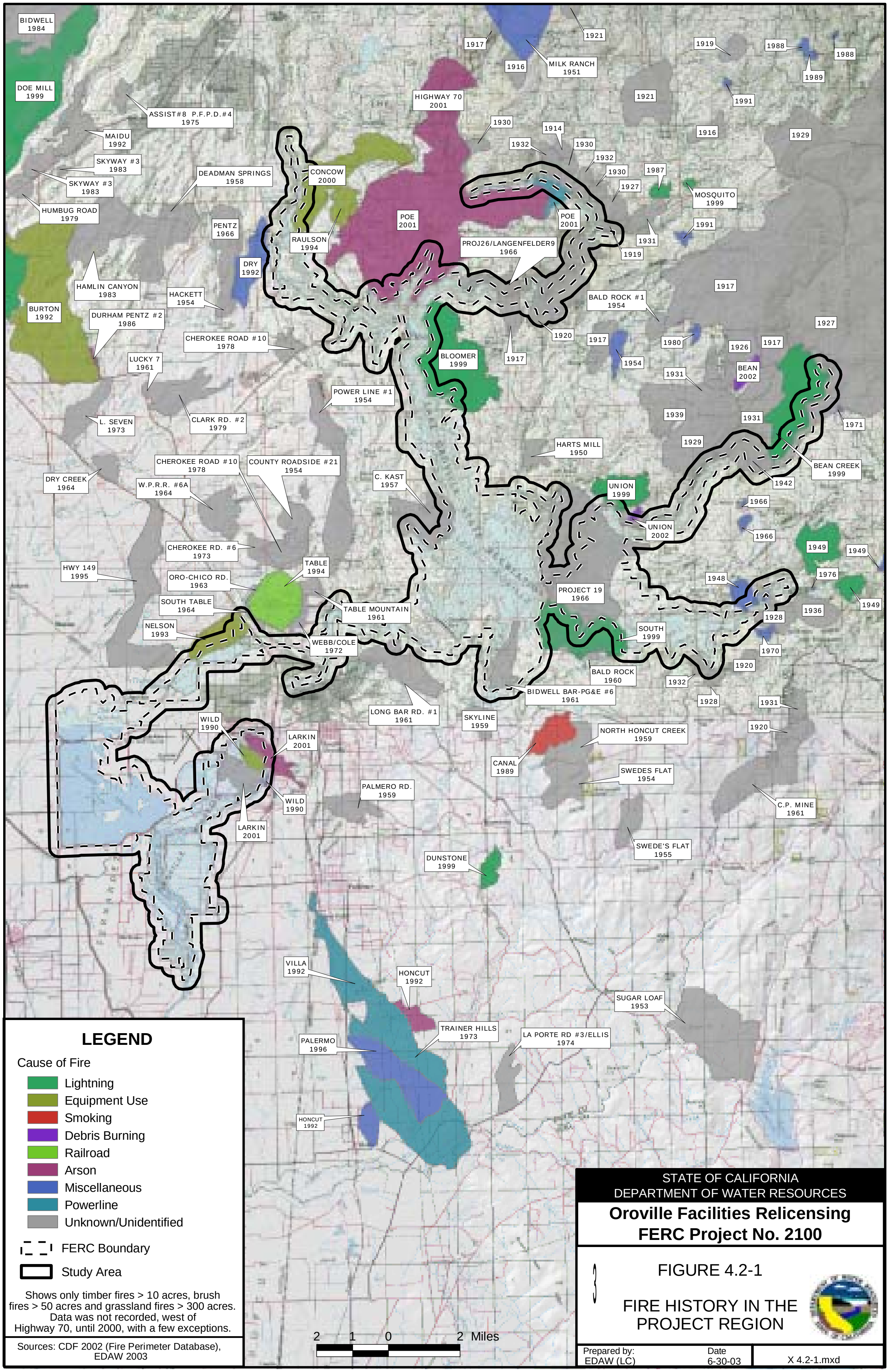
BIDWELL 1984
DOE MILL 1999
ASSIST#8 P.F.P.D.#4 1975
MAIDU 1992
SKYWAY #3 1983
SKYWAY #3 1983
HUMBUG ROAD 1979
DEADMAN SPRINGS 1958
CONCOW 2000
HIGHWAY 70 2001
MILK RANCH 1951
PENTZ 1966
DRY 1992
RAULSON 1994
POE 2001
POE 2001
PROJ26/LANGENFELDER9 1966
HAMLIN CANYON 1983
HACKETT 1954
BURTON 1992
DURHAM PENTZ #2 1986
CHEROKEE ROAD #10 1978
LUCKY 7 1961
BLOOMER 1999
BALD ROCK #1 1954
MOSQUITO 1999
BEAN 2002
POWER LINE #1 1954
L. SEVEN 1973
CLARK RD. #2 1979
HARTS MILL 1950
BEAN CREEK 1999
CHEROKEE ROAD #10 1978
COUNTY ROADSIDE #21 1954
C. KAST 1957
DRY CREEK 1964
W.P.R.R. #6A 1964
UNION 1999
UNION 2002
CHEROKEE RD. #6 1973
HWY 149 1995
TABLE 1994
ORO-CHICO RD. 1963
SOUTH TABLE 1964
TABLE MOUNTAIN 1961
PROJECT 19 1966
NELSON 1993
WEBB/COLE 1972
SOUTH 1999
BALD ROCK 1960
BIDWELL BAR-PG&E #6 1961
LONG BAR RD. #1 1961
SKYLINE 1959
WILD 1990
LARKIN 2001
NORTH HONCUT CREEK 1959
CANAL 1989
SWEDES FLAT 1954
PALMERO RD. 1959
WILD 1990
LARKIN 2001
C.P. MINE 1961
SWEDE'S FLAT 1955
DUNSTONE 1999
VILLA 1992
HONCUT 1992
SUGAR LOAF 1953
TRAINER HILLS 1973
LA PORTE RD #3/ELLIS 1974
PALERMO 1996
HONCUT 1992
1917
1921
1916
1919
1988
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1949
1948
1976
1936
1949
1928
1970
1920
1932
1928
1931
1920
LEGEND
Cause of Fire
Lightning
Equipment Use
Smoking
Debris Burning
Railroad
Arson
Miscellaneous
Powerline
Unknown/Unidentified
FERC Boundary
Study Area
Shows only timber fires > 10 acres, brush fires > 50 acres and grassland fires > 300 acres. Data was not recorded, west of Highway 70, until 2000, with a few exceptions.
Sources: CDF 2002 (Fire Perimeter Database), EDAW 2003
2 1 0 2 Miles
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
Oroville Facilities Relicensing
FERC Project No. 2100
FIGURE 4.2-1
FIRE HISTORY IN THE PROJECT REGION
Prepared by: EDAW (LC)
Date 6-30-03
X 4.2-1.mxd

Table 4.2-1. Size and cause of recent fires in the study area.

Fire Name	Year	Acres Burned	Cause
Wild	1990	30	Miscellaneous
Wild	1990	257	Equipment Use
Dry	1992	820	Miscellaneous
Nelson	1993	743	Equipment Use
Union	1999	736	Lightening
Bloomer	1999	2,610	Lightening
South	1999	1,572	Lightening
Bean Creek	1999	1,785	Lightening
Concow	2000	1,835	Equipment Use
Larkin	2001	487	Arson
Poe	2001	8,333	Powerline
Larkin	2001	627	Unknown/Undetermined
Poe	2001	8,055	Arson
Union	2002	58	Debris Burning

Source: CDF, 2002b

Fire history is added to the model to create a more accurate and current representation of fuel hazard. The fire history layer shows where vegetation has burned over a fire area, and computer modeling is used to predict the regrowth of native vegetation over the area based on principles of ecological succession. For example, after a fire occurs in an area of brush, in the following year, grass will generally dominate the area. After 5 years, shrubs are predicted to resprout, and the predominant vegetation will shift from grass to shrubs.

Once the fuel model is determined, one of the six slope classes is integrated to a particular Quad 81st using Digital Elevation Model (DEM) data to arrive at a surface fuel hazard rank. Indices for crown and ladder fuels are also added to the model to derive an overall hazard score of Moderate, High, or Very High. Figure 4.2-2 shows the CDF Fuel Hazard Ranking for Butte County.

4.2.3 CDF Fuel Hazard Ranking in the Study Area

The model described above was used to determine the fuel hazard rank for land only within the study area (Figure 4.2-3). Most of the study area (53 percent) is classified as having moderate fuel hazard, 32 percent of the area is classified as High hazard, and 15 percent is classified as Very High hazard. Table 4.2-2 shows the fuel hazard ranking classification for the study area by acres and percent of area.

The study area is divided into four general areas: (1) Lake Oroville, (2) Diversion Pool and Thermalito Forebay, (3) Thermalito Afterbay, and (4) Bypass Reach and Oroville Wildlife Area (See Figure 4.2-3). The fuel hazard ranking of the general Lake Oroville area is classified as mostly High, with some areas classified as Very High or Moderate. The majority of the Diversion Pool and Thermalito Forebay, Thermalito Afterbay, and Bypass Reach and Oroville Wildlife Area are classified as Moderate, with a small

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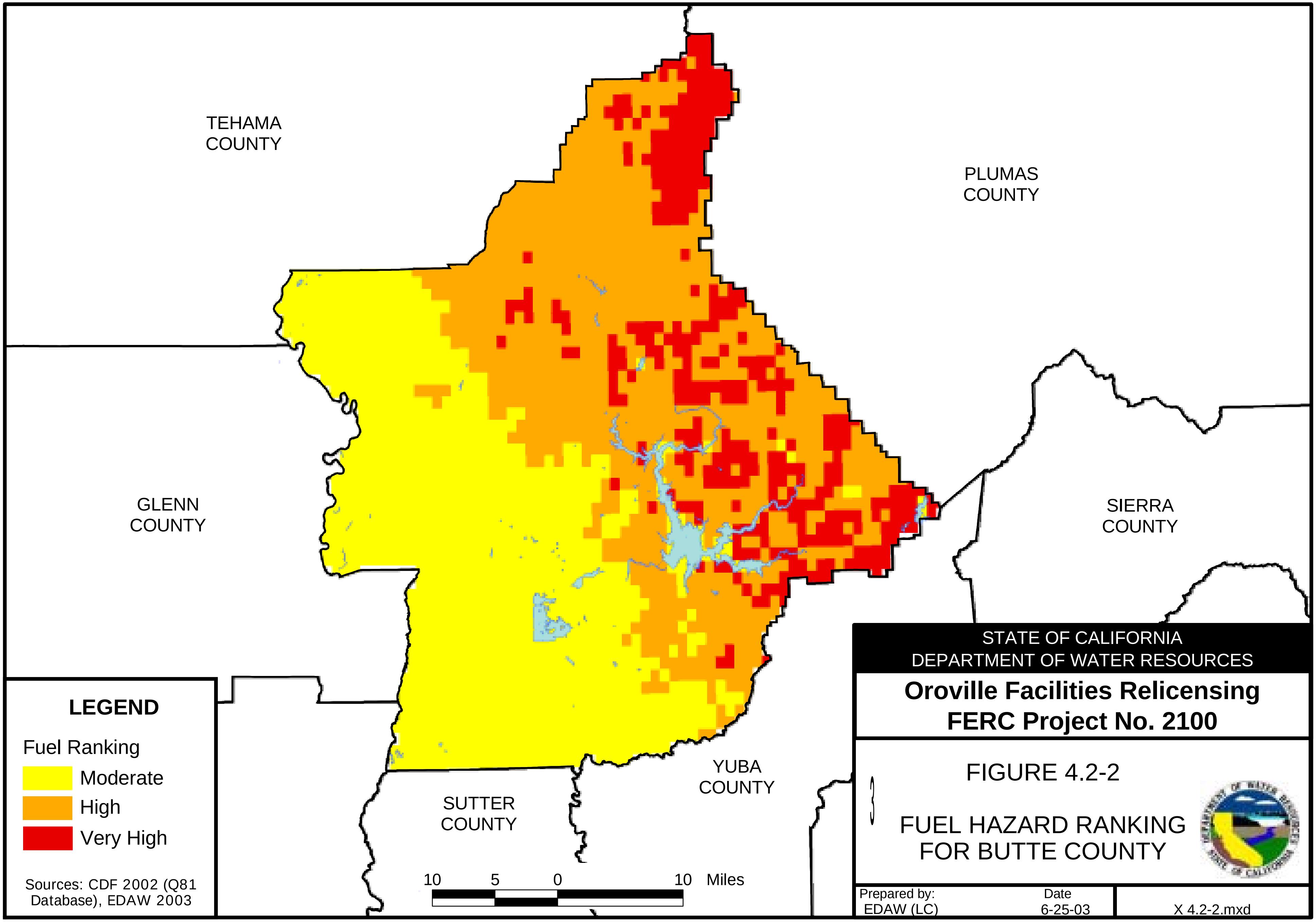
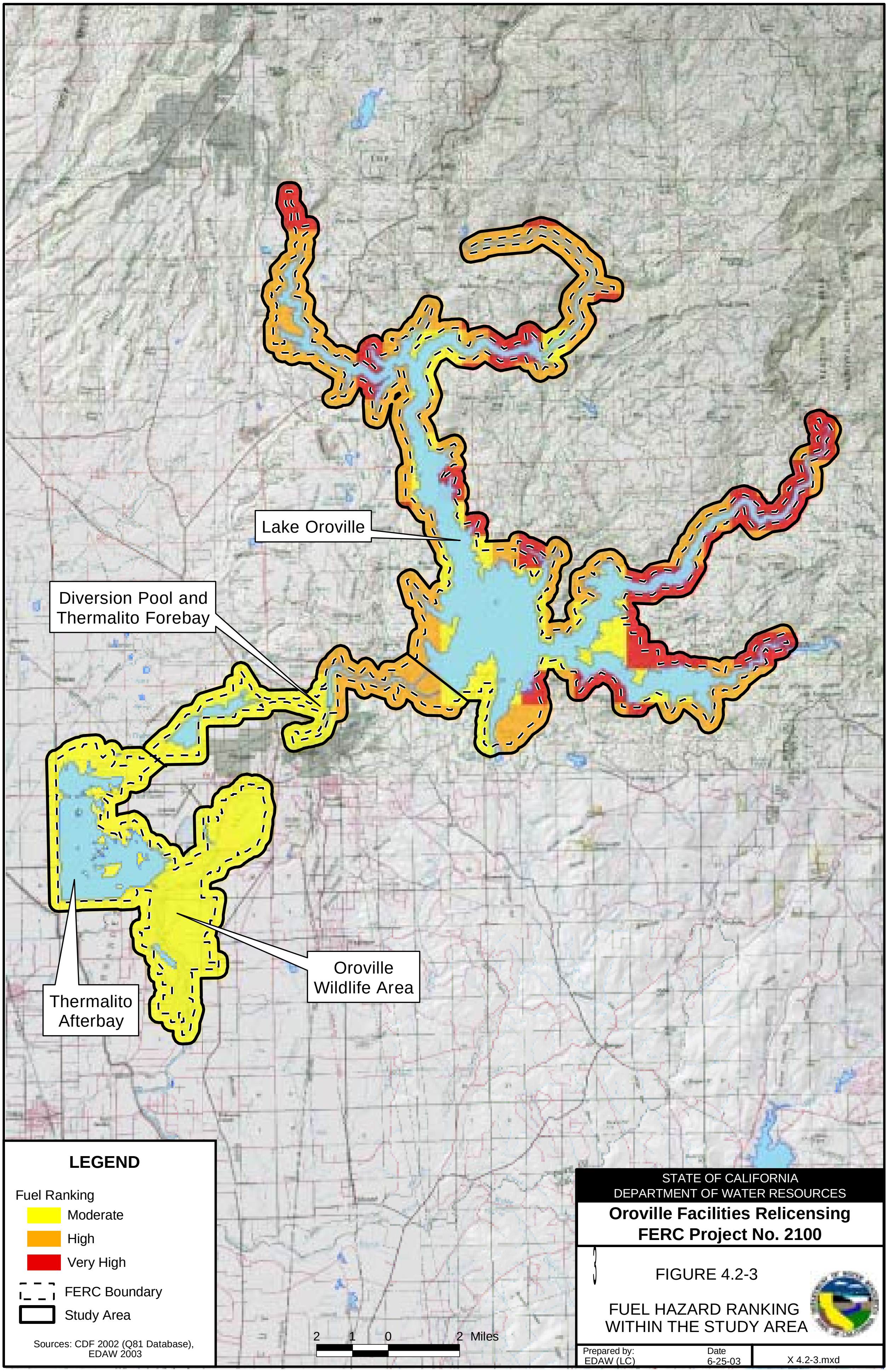

TEHAMA
COUNTY
PLUMAS
COUNTY
GLENN
COUNTY
SIERRA
COUNTY
YUBA
COUNTY
SUTTER
COUNTY
10 5 0 10 Miles
LEGEND
Fuel Ranking
Moderate
High
Very High
Sources: CDF 2002 (Q81
Database), EDAW 2003
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
Oroville Facilities Relicensing
FERC Project No. 2100
FIGURE 4.2-2
FUEL HAZARD RANKING
FOR BUTTE COUNTY
Prepared by:
EDAW (LC)
Date
6-25-03
X 4.2-2.mxd


Lake Oroville
Diversion Pool and Thermalito Forebay
Thermalito Afterbay
Oroville Wildlife Area
LEGEND
Fuel Ranking
Moderate
High
Very High
FERC Boundary
Study Area
Sources: CDF 2002 (Q81 Database), EDAW 2003
2 1 0 2 Miles
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
Oroville Facilities Relicensing
FERC Project No. 2100
FIGURE 4.2-3
FUEL HAZARD RANKING WITHIN THE STUDY AREA
Prepared by: EDAW (LC)
Date 6-25-03
X 4.2-3.mxd

portion classified as High. Figure 4.2-4 through Figure 4.2-6 show some general fuel conditions within the study area.

Table 4.2-2. Fuel hazard ranking classification within the study area.

Area	Fuel Hazard Classification Approximate percent of area (acres)		
	Very High	High	Moderate
Lake Oroville	15% (10,730)	28 (19,700)	22 (15,530)
Diversion Pool and Thermalito Forebay	-	4 (2,750)	7 (4,940)
Thermalito Afterbay	-	-	12 (8,480)
Bypass Reach and Oroville Wildlife Area	-	-	12 (8,480)
Total	**15% (10,730)**	**32% (22,450)**	**53% (37,430)**

Source: CDF 2002c

Source: EDAW 2003

Residential neighborhood on Kelly Ridge

Source: EDAW 2003

Vegetation within study area on Kelly Ridge

Figure 4.2-4. Fuel load conditions in the study area.

Source: EDAW 2003

Canyon Creek area

Source: EDAW 2003

Foreman Creek area

Figure 4.2-5. Fuel load conditions in the study area.

Source: EDAW 2003

Upper South Fork area

Source: EDAW 2003

Upper South Fork area

Figure 4.2-6. Fuel load conditions in the study area.

5.0 FUEL LOAD REDUCTION TECHNIQUES AND MANAGEMENT STRATEGIES

5.1 FUEL LOAD REDUCTION TECHNIQUES

Fuel load reduction techniques include methods to reduce the fuel load throughout a given area. Major methods include prescribed burning, pile burning, mastication, thinning, chipping and multicutting, disking and mowing, grazing, and herbicide application. Some of these treatments may be combined. For example, stands of trees are often thinned before being burned. The definitions of fuel treatments given below are from USFS (2002), California Forest Stewardship Program (Website), and Smith et al. (1997). Table 5.1-1 provides a summary of each technique and further detail regarding effectiveness, use, and cost.

5.1.1 Prescribed Burning

A prescribed burn, also known as a controlled burn, is a fire ignited by management actions to meet specific objectives, such as removal of underbrush or exotic species (Figure 5.1-1). In forested areas, prescribed fires that are not lethal to dominant vegetation and do not substantially change the structure of the dominant vegetation are sometimes called an underburn. Approximately 80 percent of the aboveground vegetation is expected to survive an underburn fire. Using this technique, fire lines are constructed to contain the fire area, and the burn is targeted to remove shrubs and trees up to 6 inches diameter at breast height (dbh). Prescribed burns may also be used in grassland areas, especially to control weeds, reduce hazardous fuels, promote nutrient cycling and/or germination of native species, and improve wildlife habitat.

Prescribed burning must be used with great caution due to the risk of losing control of the fire. Experienced personnel are required to be on site for fire management. Prescribed fires should only be set when conditions are safe. These conditions include low temperature, low wind, high humidity, or moisture (CDF Website). Prescribed burning can be applied to most terrains. In wooded areas, prescribed fires are only recommended in mature forests with low ground vegetation and areas where fuels have not accumulated to create hazards of crown or high-intensity fires. Burning should only be applied to stands with a fire-resistant age composition. Smaller trees (less than 9 inches dbh) may be subject to mortality, and very large trees (greater than 18 inches dbh) may be subject to damage from the fire and subsequent growth may be slowed. Due to the potential of the fire to kill some individual trees and damage others, prescribed burning should be applied to stands with trees ranging from 9-18 inches dbh (Smith et al. 1997).

Prescribed burning may result in adverse impacts to air quality and wildlife. Wildlife species that are too slow to escape (some reptiles and amphibians) or that nest on the ground (small rodents and some birds) may be affected during the fire by direct mortality or after the fire by increased vulnerability to predators from the loss of shelter habitat. Predators, such as raptors, will benefit from the fire by easier access to prey [University of Florida Cooperative Extension Service (UFLCES) Website]. Animals that forage on young vegetative growth may also benefit from enhanced food availability after a fire.

Table 5.1-1. Fuel load treatment technique comparison.

Method	Vegetation Type	Terrain	Advantages	Disadvantages	Relative Cost
Prescribed Burn	Mature forest with low ground vegetation; prairies and grasslands	All	Promotes germination, flowering, resprouting; deer browse habitat; pest and disease control; increased open space; effective for multi-tasking; can mimic natural regime	Condition constrained; danger of losing control; require experienced personnel; potential for slow growth or mortality of larger trees; wildlife mortality or increased predation; adverse impacts to air quality and smoke	$60-400/acre
Pile Burn	Woody shrubs and trees	All	Nutrient recycling; promotes regeneration; easy to implement	Labor-intensive; impenetrable soils from heat compaction; causes more hazard if not burned; rodent and bird mortality; follow-up treatment; land scars	$25-2,000/acre
Mastication	Intermediate to mature forests	Level to moderately sloped, non-rocky	Least adverse effects on soils; nutrient recycling; efficient	May require follow-up treatment; dangerous to workers; excessive downtime and ineffective if used on rocky sites	$500/acre
Thinning	Young- to intermediate-aged forests	All	Increased growth of mature trees; park-like results; low risk	Change species composition; requires roads; soil disturbance and erosion; must have a market for removed trees; labor-intensive; secondary treatment needed	$230-850/acre
Chipping & Multicutting	Brush, intermediate and mature forests	Chipping: level to moderately sloped Multicutting: steep slopes	Nutrient recycling; chips left on site prevent erosion; alternative to burning; effective for multi-tasking	Soil disturbance and erosion; requires roads; can spread weeds; damage to leave trees	$575-1,600/acre
Disking & Mowing	Grasses, forbs, brush, saplings	Relatively flat, open areas	Loosens compacted soil; nutrient recycling	Topsoil disturbance; secondary treatment needed; encourages weed growth	$10-30/acre
Grazing	Meadows and grasslands to moderately open forests	Level, moderate, steep (<60% slope)	Nutrient recycling; wide range of options for different objectives;	Management or herding is needed; requires fencing and water; political or social challenges; multiple treatments required; only effective with palatable plants; soil compaction	$200-300/acre
Herbicides	Any	Any	Good for pre- and post - treatment of other methods; no soil disturbance;	Frequently requires secondary treatments; regulated; political and social challenges; impacts to water quality	$2-50/acre

Source: Applegate Valley Website, CDF website

Source: University of Wisconsin Steven's Point Fire Crew Website

Prescribed burning

Source: Joel McNamara 1997

Pile burning

Figure 5.1-1. Fuel load reduction techniques – prescribed burning and pile burning.

Fire can be used in a manner that mimics natural processes. Prescribed burning is an ecological management tool that can reduce fire frequency and intensity, as well as promote native grass establishment, improve wildlife habitat, and improve the plant communities by age class and diversity [East Bay Municipal Utilities District (EBMUD) Website]. Successful prescribed burns allow for less severe and less frequent subsequent fires by the control of fuel load.

Historically, natural fires burned the forests at a relatively regular frequency, creating fire-dependent communities and ecosystems. Through succession, forests recuperate from disturbances such as fire, which results in changes in the plant community. Burned stands tend to regenerate to the same tree species that were dominant before the fire. High-severity fires tend to favor the re-establishment of conifers with serotinous or semi-serotinous cones, in which the cones require fire to open and release seeds for regeneration. Low-severity fires tend to favor the re-establishment of hardwoods and woody shrubs that reproduce by suckering, sprouting, or seed banking (Luke et al. 2000).

The surge of vegetation that follows a disturbance such as fire can improve browse habitat for deer and increase the food supply for some wildlife species by increasing the availability succulent vegetation, nuts, and fruits. Pest control is accomplished by burning, which reduces the incidence of foliage diseases, insect infestations, fungal growth, and other pests. Fire improves access within the forest by increasing openings for wildlife, natural regeneration of vegetation, and recreation visibility (UFLCES Website).

Controlled burns are relatively economical, costing from $60 to $400 per acre depending on location, topography, conditions, and the need for adjacent land protection (Applegate Valley Website). Prescribed burning may be the most cost-effective fuel treatment for an area, especially those managed for ecosystem sustainability and restoration of natural processes where mechanical methods are not suitable (e.g., National Parks) (Omi et al. 1999). There are, however, potential negative effects on air quality and risk of loss and liability if the fire gets out of control, moves to adjacent properties, and results in property damage (CDF Website). Regardless, numerous studies with the U.S. Fish and Wildlife Service (USFWS), USFS, and BLM have shown that the per acre cost of suppressing fires is 4-10 times the cost of planned prescribed fire (Omi et al. 1997).

5.1.2 Pile Burning

Pile burning is a method in which material is cleared and placed into piles either by hand or mechanically, and then burned (Figure 5.1-1). This method is used on most terrains for shrubs and small trees (usually 6 inches dbh or less, sometimes up to 12 inches dbh). Pile burning reduces the concentration of surface and ladder fuels. In addition, nutrients are recycled into the soil by pile burning because the fuels remain on site, are broken down, and remain part of the ecosystem.

Pile burning is a labor-intensive option and usually requires a follow-up treatment; however, mechanical equipment can be used (Smith et al. 1997). Hand removal is expensive and provides little additional benefit compared to mechanical removal, except when working in sensitive areas. Pile burning returns nutrients to the soil and exposes mineral soils, which promotes regeneration of grasses and shrubs; however, the intense heat from the fire consolidated in one place can result in black scars on the land and severely compacted soils. The soils may become impenetrable to water for many years, adversely affecting water uptake of surrounding vegetation and reducing the germination of seeds (CDF Website; Smith et al.1997).

Piling materials in advance of burning can increase fire hazards if they are not burned immediately, left on the forest floor due to a delay of funding, or because of unsuitable weather conditions. The piles may become untreated high-risk fuels. In addition, some wildlife species, such as rodents and birds, will nest or den in large slash piles for protection. Protection of resident wildlife, especially special-status species, can cause management challenges when the conditions allow for the piles to be burned (Fox and Ingalsbee 1998; Smith et al.1997).

Pile burning can cost from $25 to $2,000 per acre, depending on the method of removal. Hand removal is more labor-intensive and therefore more expensive (Applegate Valley Website). Pile burning can be a less-expensive alternative to broadcast or prescribed burning but may result in soil compaction. Small fires that are fed the piled material (instead of igniting the entire pile) may create less intense fires and prevent overheating of the site [University of California, Forest Products Laboratory (UCFPL) Website].

5.1.3 Mastication

Mastication is a mechanical method of fuel load reduction that involves a bulldozer or tractor with a special attachment called cutting head (Figure 5.1-2). The cutting head is placed over trees or shrubs, grinds them into mulch, and presses the mulch into the ground. The masticator can clear brush, shrubs, and small trees up to 10 inches dbh. Mastication can be used to achieve crown separation and desired canopy cover levels on moderately sloped (<40%), non-rocky terrains.

Mechanical methods that involve large machinery and roads, such as mastication, generally result in ground disturbance, soil compaction, and soil erosion. The disadvantages of mastication are few; however, it is costly compared to other mechanical methods, requires specialized equipment, and may require a follow-up treatment such as herbicide or prescribed burn (CDF Website). In addition, the technique has limitations on rocky sites. If the cutting head is used at ground level, it may dislodge rocks, which can endanger workers. The rocks may also damage the cutting head and delay the project. Alternatively, if the cutting head is kept above the rocks, plants will not be cut close to the ground surface, and the desired result may not be achieved (USFS Website).

Source: California Forest Stewardship Program Website

Masticator

Pre-thinning (left) and post-thinning (right) treatment

Figure 5.1-2. Fuel load reduction techniques – masticating and thinning.

Of the available mechanical methods (e.g., thinning, chipping), mastication has the least adverse effect on soils. This method allows for the fuel to remain on site but in a less hazardous form as mulch. The ladder fuels are removed from a position where they are a pathway to the canopy. Mastication is an efficient and effective pretreatment for prescribed burning and reduces germination of brush species.

Mastication costs approximately $500 per acre, which is expensive compared to other mechanical options; however, it is very efficient and has the least adverse effects on soil compared to other mechanical methods (CDF Website). This method is best used in densely vegetated, non-rocky areas where prescribed fire is not suitable.

5.1.4 Thinning

Thinning is a method used to remove biomass from a stand to achieve crown separation and desired canopy cover levels (Figure 5.1-2). Trees are removed to reduce competition among target species for sunlight, water, and soil nutrients. Often trees are thinned to have a spacing of between 16 and 22 feet. Trees to be thinned are usually 6 inches dbh or less, occasionally up to 12 inches dbh. Thinning of trees or excess brush may be done by hand or mechanically. Thinning from below is a process that begins with removal of smaller trees but includes removal of trees up to 30 inches dbh. Thinning can be used in dense, multi-aged forests and on most terrains, depending on how the trees are removed from the site.

Generally, the result of thinning is increased growth in diameter and height of the remaining trees. The amount of growth that results from thinning varies by the tree species, age, and condition. Generally, younger trees respond more to thinning compared to older and more established trees. Shade-intolerant species also respond more readily to thinning due to the increase in light available. The species composition of a stand may be changed after thinning, depending on the trees that are removed (CDF Website).

Like other mechanical treatments, thinning requires a road system for equipment access, which may cause soil disturbance and soil erosion in wet conditions. Thinning also increases the stand exposure to sunlight, which may reduce moisture levels, increase temperatures, and result in a higher potential for wildfire ignitions. Thinning of large-sized trees is often done for commercial purposes and is generally focused in high value timber areas, leaving the low value areas in danger of fire with hazardous fuel loads (Fox and Ingalsbee 1998). Thinning for fuel load management generally yields smaller diameter trees, which are difficult to market. The sale of timber could alleviate the costs of the fuel load removal. If the timber is not sold to a commercial market, it may remain on the forest floor due to lack of funds to remove it. This would thereby increase, rather than reduce, the fuel load.

Thinning is a low-risk method compared to prescribed fire. It results in more open forests with less understory growth and allows for increased growth of canopy trees. However, it is disruptive to the site, requires a secondary treatment, and is moderately expensive ($230-850 per acre) (Applegate Valley Website). The cost-effectiveness of thinning is low compared to other mechanical methods and requires a local market for smaller trees (Fox and Ingalsbee 1998).

5.1.5 Chipping and Multicutting

Chipping and multicutting leave the cut material in place rather than removing it from the site (e.g., as occurs in thinning). Chipping involves grinding shrubs and small trees into small pieces, which can then be used as mulch or ground cover (Figure 5.1-3). Multicutting is similar, except that shrubby material is chopped into smaller pieces by hand and left in place as mulch. It is particularly useful on steep hillsides.

Chipping and multicutting involve large machinery, such as bulldozers to fell trees that are then chipped or crushed. Both techniques can be applied to intermediate to mature forests, on level to moderately sloped terrain (Applegate Valley Website). Chipping is usually done along roads, and the chips are used as road cover to prevent erosion. This allows the nutrients to be left on site and is efficient for accomplishing multiple tasks at once. Multicutting is more labor-intensive than chipping. Material is manually cut into lengths no longer than 6 inches. Ideally, the cut material is left 3 inches deep and acts as mulch by absorbing rain and precluding sunlight from regenerating fuels and exotic plants. Multicutting works well on steeper slopes and areas not easily accessed with machinery (CDF Website; UCFPL Website).

Chipping and multicutting require roads and machinery access, resulting in soil erosion and disturbance. These methods are also prone to spreading weeds and can damage remaining trees. Chipping or multicutting is often used when burning is not feasible due to constraints in conditions or lack of experienced personnel (Smith et al.1997). Due to the high level of manual labor, the cost of these techniques is high ($575 to $1,600 per acre) (Applegate Valley Website).

5.1.6 Disking and Mowing

Disking and mowing are fast methods to clear areas and reduce fuel biomass while returning nutrients to the soil. Disking is a rapid and economical way to loosen compacted soils while removing vegetation (Figure 5.1-3); it is the most widely used mechanical method (UCFPL Website). Plants of sapling size (<0.5 inch dbh) and smaller are broken down and folded into the soil. Mowing removes the top portion of the vegetation but leaves the roots intact. Both of these methods work best on relatively flat and open terrain and for grass and low, shrubby vegetation.

Disking and mowing involve mechanical equipment, which as mentioned previously causes disturbance to the land, including soil erosion and compaction. Although these methods can cover large areas fairly quickly, large mechanical equipment is regarded as more potentially damaging than fire, herbicides, or other tools (UCFPL Website; Smith et al. 1997). Disking disturbs topsoil and encourages weed growth, so a secondary treatment is usually needed. Secondary treatments can be accomplished with another disking, burning, or herbicide application.

Source: Friends of Leckhampton Hill & Charlton Kings Common Website

Chipping

Source: Swainsboro Forestry Technology Program Website

Disking

Figure 5.1-3. Fuel load reduction techniques – chipping and disking.

Mowing is an effective treatment, but it is limited to use only on flat open areas with slopes less than 30 percent (CDF Website). It is recommended for picnic and recreation areas, trailheads, and along trails. Mowing requires annual upkeep and leaves a distinct unsightly edge between areas mowed and not mowed (UCFPL Website). The size of vegetative material that a mower can handle generally includes grasses and forbs and possibly small seedlings or very young saplings (< 0.5 inch diameter). Mowing spreads seed and encourages new growth and sprouting. Follow-up treatments would be needed to keep fuel loads at a safe level.

Mowing and disking are both relatively inexpensive ($10-30/acre), depending on the labor costs and machinery used [University of Florida (UFL) Website]. Disking is more effective than mowing at stopping the spread of fire because it breaks the horizontal continuity of the vegetation, whereas mowing simply reduces the plant height (EBMUD Website). However, disking has more adverse impacts to soil and ground-burrowing wildlife compared to mowing. Both methods can only be applied to open, flat areas and are similarly cost-effective.

5.1.7 Grazing

Grazing animals, such as goats, horses, or cows, can be used to remove vegetation in meadow, grassland, and open forest areas (Figure 5.1-4). Grazing is less effective on steep terrain (>60 percent slope) and woodlands in excess of 50 percent cover. Several options are available, depending on the management goals and limitations of the site. Horses and cows typically graze on grasses and not shrubby materials, but goats will consume shrubs and thorny plants. Goats are particularly effective at removing vegetation from steep slopes. Often, animals are kept in an area by a temporary fence, such as a portable electrified fence, and moved accordingly.

Grazing can be a revenue-generating option by leasing land to ranchers (EBMUD Website). Grazing returns nutrients to the soil through animal waste and can reduce fuel load significantly; however, gazing animals eat all types of vegetation, including desirable plants. Grazing is considered a natural way of managing fuel load levels. Carefully managed grazing programs can restore degraded ecosystems to historical conditions. For example, it has been used to convert non-native annual grasslands to perennial bunchgrass communities [New Mexico Environment Department (NMED) Website].

Goats can be used to graze small, confined areas and steeper slopes. Their range of palatable vegetation is wide compared to cattle, including grasses, forbs, brush, and trees. Goats will strip the landscape and cause erosion if left alone without a herder [California Air Resources Board (CARB) Website]. Livestock, such as cattle and horses, can be less management-intensive than goats. They can be used on grassland sites up to 35 percent slope. Cattle have a limited range of palatable vegetation, preferring grasses and forbs. Cattle can be used on large free-range lands and require management to keep them from eating and trampling valued woody plants (CDF Website). Horses prefer grasses and will not eat shrubs or woody plants; therefore,

Source: Queensland Department of Forestry Website

Grazing

Source: USFS Southern Research Station Website

Herbicides

Figure 5.1-4. Fuel load reduction techniques – grazing and herbicide application.

they cannot clear a site but are effective at maintaining grassland (CDF Website, UCFPL Website).

Grazing can damage sensitive habitats and is not best suited for urban interface areas due to noise, odors, and dust that are incompatible with nearby residences. Excessive use by grazing animals can also lead to soil compaction and erosion. Animal waste may return nutrients to the soil, but may also contaminate water sources. Permanent or temporary fencing and water access are needed to contain the grazing animals, which can be a costly and time-consuming option. In addition, herd management is needed to prevent livestock from denuding that land. Other disadvantages include the need for multiple treatments when used as a primary vegetation removal technique, and no effect on species that are not palatable to the grazing animals (CARB Website).

Grazing can cost up to $200 to $300 per acre, depending on revenue made from ranchers and the availability of water and fencing (Applegate Valley Website). Grazing also requires 5 or more acres of land and requires on-site management to prevent damage to the land. However, grazing provides options and can be a cost-effective method of fuel load management on meadow and grassland areas.

5.1.8 Herbicide Application

Herbicides are chemicals designed to kill or inhibit plant germination. Herbicides are designed to target specific species, or can be general mixes for broad application. Herbicides may be injected into stems, applied to the surface of freshly cut stumps, placed in a continuous ring around the basal bark of a tree, applied directly to soil to be taken up by plant roots, or applied to foliage. Herbicides can be used on any vegetation type or terrain.

Plants respond in varying ways to herbicides, depending on species' susceptibility and environmental conditions. They do not remove vegetation alone but are generally used as a pre- or post-treatment. Using herbicides prior to burning (brown and burn) allows for a more efficient burn, reduces smoldering, and provides for good smoke management (CARB Website). Herbicides can also be used post-logging or post-burning to control the abundance of vegetative growth that follows the disturbance (CARB Website). However, if used as a primary method for broadcast removal of all vegetation, herbicide-resistant weeds can take over the site (UCFPL Website).

Herbicide removal of competing vegetation does not result in effects on forest floor conditions, unlike most mechanical methods (Smith et al. 1997). The costs of herbicides and the associated labor and equipment needed for their application can be expensive when compared to other methods.

Certain regulations apply to the use of herbicides for protection of the applicator and the environment, including water quality. Public controversy over the risk of herbicides to human health, bioaccumulation, and lethal effects to adjacent plants can deter the use of herbicides when the treated area is near urban areas (NMED Website). Although studies have shown that herbicides used in forestry practices are non-toxic to wildlife, do not bio-accumulate, and are eliminated quickly, wildlife may be indirectly affected through habitat modification (McNabb 1997).

Herbicides are often used in combination with other techniques when they are used to kill vegetation either prior to or following another treatment, such as burning or disking. When used alone for fuel load management, herbicides frequently require secondary treatments. The cost of herbicides varies greatly ($2 to $50), depending on the type of vegetation treated, the kind of herbicide used, and the application method (Taylor and Koo 2001).

5.2 LANDSCAPE LEVEL FUEL LOAD MANAGEMENT STRATEGIES

Fuel load management strategies refer to methods for prioritizing or locating fuel treatments on a landscape scale to increase their overall effectiveness for reducing the extent of severe wildfires. Most past fuel management in the Sierra Nevada has not involved strategic planning, but has been a response to removal of fuels after a timber sale or other specific activity. With the recent move toward ecosystem management, fire managers and foresters have begun to address forest health concerns, including fuel management at a landscape level (Weatherspoon and Skinner 1996).

Three general approaches have been used: (1) identifying fuel-management approaches appropriate within each of several landscape zones defined by general characteristics, uses, or emphases; (2) setting priorities based on various combinations of risk, hazard, values at risk, and suppression capabilities; and (3) employing a fuelbreak-type concept intended to interrupt fuel continuity on the landscape scale and to limit the size of fires by providing defensible zones for suppression forces (Weatherspoon and Skinner 1996).

5.2.1 Strategies Based on Zones

This strategy for landscape-level fuel load reduction proposes three landscape zones. Zone I includes wilderness and natural areas; fire management in this area would emphasize natural fire, augmented by management-ignited prescribed fire to restore the natural role of fire to the ecosystem. In Zone II, the general forest management zone, fuel management would be planned and implemented in conjunction with proper timber harvests. In Zone III, the residential forest, homeowners, and local officials would be educated about the realities of fire hazards in the wildland-urban interface, and aesthetically pleasing manipulations of fuel loads would be established, such as shaded fuelbreaks (See definition in Section 5.2.3). Other variations of this strategy create zones based on structure density or the degree of modification to the natural processes (Weatherspoon and Skinner 1996).

5.2.2 Strategies Based on Risk, Hazard, Values at Risk, and Suppression Capabilities

Decision analysis has been used by some to aid in fuel-management decisions. This analysis involves using topography, historical weather, historical fire occurrence (risk), suppression capability, and fuel hazard to determine probabilities of various fires by intensity class. This information is intended to provide a consistent means of evaluating the important factors affecting fuel-treatment decisions. In addition, sometimes acceptable resource loss will determine treatment options. Some of these strategies assign a point system to calculate catastrophic fire vulnerability rating based on qualitative assessments of risk, hazard, value, and suppression capability (Weatherspoon and Skinner 1996).

5.2.3 Strategies Based on Fuelbreaks

A fuelbreak is defined as a wide (generally 60 to 1,000 feet) strip of land on which native vegetation has been permanently modified so that fires burning into it can be more readily controlled (McPherson et al. 1990 *in* Weatherspoon and Skinner 1996).

The term “shaded fuelbreak” is also used to describe creation of an area where fuels are removed to provide a reasonable likelihood of stopping a fire. Shaded fuelbreaks typically leave some larger trees within a given area, but are not necessarily designed to provide fire fighters a safe space from which they can fight the fire. The creation of shaded fuelbreaks in narrow strips (200 to 400 feet) is considered by some to be too narrow to effectively stop a fire under many conditions; other strategies discussed below suggest a width of 1/4 mile (Weatherspoon and Skinner 1996). A shaded fuelbreak is also usually considered to be a stand-alone treatment for a specific area, rather than a strategy applied over a larger landscape.

There are many ways that fuelbreaks can be arranged on the landscape. The Quincy Library Group, a community-based group representing a wide range of interests, has suggested a network of defensible fuelbreaks [Quincy Library Group (QLG) 1994]. In 1995, the Lassen National Forest, Plumas National Forest, and Sierraville Ranger District of the Tahoe National Forest published a Technical Fuels Report, which describes fuel reduction strategies based on Defensible Fuel Profile Zones (DFPZ), Community Defense Zones (CDZ), and Fuel Reduction Zones (FRZ) (Olson et al. 1995 in Weatherspoon and Skinner 1996). Other landscape treatments used by the USFS include Strategically Placed Area Treatments (SPLATs) and group selection (USFS 2002). Each of these strategies is described below. They all involve use of mechanized, ground-based felling, skidding, and piling equipment on slopes less than 35 percent. On slopes greater than 35 percent, helicopter equipment is generally used.

5.2.3.1 Defensible Fuel Profile Zones and Fuelbreaks in Other Zones

DFPZs consist of a network of corridors along roads and ridges that inhibit fire spread and provide a defensible area for fire suppression. The width of the fuelbreak is generally 1/4 mile but may vary based on expected suppression strategies, topography, and other site-specific conditions. DFPZ creation involves thinning surface fuels and ladder fuels; it may also include thinning the canopy to achieve desired canopy separation. DFPZs are not designed to stop an oncoming fire by themselves, but rather to provide a safe location to facilitate fire suppression efforts and provide an anchor point for prescribed burning projects (USFS 2001). DFPZs are intended to be installed over a period of just a few years and provide a framework for the landscape treatment.

They are not intended to replace other fuel treatments; rather, they are intended to increase the effectiveness of initial treatments and to facilitate subsequent treatment of adjacent areas (Weatherspoon and Skinner 1996).

Another component of this strategy is creation of CDZs in urban interface areas within or near National Forest boundaries. Similar in concept to a DFPZ, a CDZ is designed to reduce the threat of wildlfire spreading onto National Forest land from private land, or vice versa. The involvement and cooperation of local communities is essential to the successful implementation of CDZs (Weatherspoon and Skinner 1996).

A third type of zone, the FRZ, refers to a general area of fuel treatment that would take place mainly after DFPZs and CDZs are in place, because those systems have higher priority for protecting the landscape at large and the urban interface. FRZs would be created within areas of the forest that need treatment, and would not provide a linear defense system like DFPZs, or specifically protect surrounding communities likes CDZs. However, the objectives of FRZ creation are similar to DFPZs and CDZs in that surface and ladder fuels are reduced and canopy separation is created to provide a broad area where a fire could be effectively and safely be suppressed (Weatherspoon and Skinner 1996).

5.2.3.2 Strategically Placed Area Treatments

SPLATs, or area fuel treatments, are areas where fuels are reduced to inhibit fire spread. Rather than strips of land like DFPZs, SPLATs are strategically placed blocks of land, ranging from 50 to over 1,000 acres. The treatment areas are placed to prevent a fire from spreading from the bottom of the slope to the ridge top to reduce continuous areas of hazardous fuel load conditions. SPLAT creation includes thinning surface and ladder fuels and reducing canopy cover if needed. Managers consider historic fire regimes and the potential for severe fires (based on fuel load, prevailing wind direction, and terrain features) in deciding where to place area treatments (USFS 2001).

5.2.3.3 Group Selection

Group selection is a system used by foresters to create uneven-aged stands. Group selection is intended to create and maintain a sustainable, small patch mosaic of all-age, multistory forest structure; to provide a source of forest products; and over time, to improve the forest's resistance to fire. In the treatment regimes proposed by the Lassen and Plumas National Forests, an average rotation age of 175 years would be targeted. Specific group selection treatments would create 1/2 to 2-acre groups. Over the long term, the result would be 9 to 18 groups of similar-aged vegetation (i.e., cohorts), depending on the selection treatment regime, across the landscape over the next 175 years. However, the group selection treatment is also designed to preserve and promote future development of older components of the forest by using an upper-diameter limit to retain existing trees that are larger than would be expected to grow in 175 years (USFS 2002). Group selection is typically used on very large areas (thousands of acres), but the size of the groups depends on the objectives.

5.2.4 General Discussion and Evaluation of Fuelbreaks

Limited information is available on the new concepts for fuelbreaks due to the continued discussion of how to use fuelbreaks in landscape-level fire control. Therefore, the majority of the information provided in the section is derived from Weatherspoon and Skinner (1996).

Fuelbreaks are typically located along ridge tops. A strip of land is cleared of fuel either mechanically or manually to create a retarding area that would slow or stop wildfires and provide a place for firefighters to defend and protect from the fire spreading. The effectiveness of fuelbreaks was documented by wildfire incidents in the 1960s and 1970s and was generally effective in stopping wildfires, except under extreme conditions. To be successful, fuelbreaks must be properly installed, properly maintained, and adequately staffed by suppression forces (Weatherspoon and Skinner 1996).

Fuelbreaks in general have not been used in the Sierra Nevada over the past 20 years for several reasons: fuelbreaks must be staffed with suppression forces in order to be effective, previous recommended widths were too narrow to be successful, competition with other area-wide treatments, and lack of focus on benefits to other resources besides fire control (Weatherspoon and Skinner 1996). They are also mostly ineffective in extreme fire behavior [California Fire Resource Assessment Program (FRAP) Website]. Spatial placement and frequency of maintenance largely affect the success of fuelbreaks. Fuelbreaks are not an alternative to strategic fuel treatment, but are most effective when accompanied by strategic fuel management. When designed as part of a community plan, fuelbreaks can be efficient and cost-effective in protecting homes and other structures from wildfire (Graham and McCaffrey 2003).

Fuelbreaks have been revisited as a potential fire control method over the last 10 years, due to several large severe fires in California, protection requirements for spotted owls, and the establishment of the Quincy Library Group. The original concept of fuelbreaks is being modified and improved to alleviate the previous disadvantages to the extent possible. A linear programming model predicted that increasing the width of a fuelbreak reduced the area affected by a fire (Weatherspoon and Skinner 1996). The Quincy Library Group proposed an intensive program to install a network of fuelbreaks approximately 0.25 mile wide and along most roads to break up fuel continuity (Weatherspoon and Skinner 1996).

The fuelbreak concept, with input from the Quincy Library Group proposal, has evolved into various types of fuel protection zones, including DFPZs, CDZs, and FRZs. Benefits of DFPZs include reducing the severity of wildfires within treated areas, providing broad zones within which firefighters can conduct suppression operation more safely and efficiently, effectively breaking up the continuity of hazardous fuels across a landscape, and providing anchor lines to facilitate subsequent area-wide fuel treatments (Weatherspoon and Skinner 1996).

DFPZs have not been widely implemented so limited information is available on their effectiveness. However, they are expected to be safer for fire suppression personnel due to the low fuel levels, less snags, and more resistance to crown fires. It is anticipated that DFPZs will also improve the efficiency and productivity of suppression forces by providing a higher potential to build and hold a fire line and more open canopy for aerial retardant drops to be more effective (Weatherspoon and Skinner 1996). Fuelbreaks are used as indirect attack lines for controlling fires that are set as a method of reducing the spread of a wildfire (e.g., back fires). They also form good boundaries for fuel management units (FRAP Website).

Other benefits anticipated from the use of DFPZs include: open conditions similar to presettlement forests, reduction in evapotranspiration leading to increased water yield, less water quality impacts due to greater distance from streams, overall habitat diversity, aesthetic variety, timber stand improvement, and possibly slower movement of insect infestations (Weatherspoon and Skinner 1996).

The long-term effects, length of effectiveness, and frequency of maintenance for strategic fuel treatments combined with landscape level fire management are not fully understood. However, it is evident that these techniques can effectively disrupt fire growth and change fire behavior (Graham and McCaffrey 2003). The largest drawbacks to DFPZs are the economic viability of smaller trees being removed and the maintenance of the treated areas. Essentially, these are challenges related to any fuel load management technique or strategy; however, it is important that they be resolved. DFPZs are expected to be less costly to maintain due to the relative continuity and accessibility. Fuelbreak construction can increase timber values by reallocating resources to larger, faster-growing, and more valuable trees. Therefore, the cost of implementing and maintaining fuelbreaks can be offset by the increase in timber value (Weatherspoon and Skinner 1996).

5.3 Overall Summary of Effectiveness of Fuel Load Management

Many researchers and professionals have concluded that, overall, pretreatment and fuel load management reduce the intensity and severity of wildfires as well as reduce impacts to valued resources. Benefits of fuel treatments are assessed by examining subsequent fire behavior, physical effects on resources, economic losses, enhanced forest health, and increased firefighter safety (FRAP Website).

Numerous field accounts yield evidence that fires were reduced in severity when they burned into areas previously burned or treated (Agee et al. 2000, FRAP Website). The CDF has compiled 26 reports documenting the benefits of the Vegetation Management Program (VMP) associated with reduced fire size and increased resource protection during wildfire events (FRAP Website). In the case of the 2002 Haymen fire in Colorado, several areas that had fuel treatments illustrated the relationship between surface, ladder, and crown fuels. An area treated with a prescribed burn the previous year and an area mechanically thinned were both successful at stopping or reducing the fire when it came through. However, a third site where smaller trees were removed from the canopy and left on site experienced 100 percent mortality due to the large amount of surface fuels (Graham and McCaffrey 2003).

Fuel treatments that remove ladder fuels reduce the potential for crown fires, which are difficult to control and devastating. According to Omi et al. (2002), crown bulk density is not the most strongly correlated variable to fire severity; height to live ratio crown is the determining factor for crown fire initiation. Therefore, treatments that reduce crown density (e.g., thinning) would be ineffective without accompanying treatments for surface and ladder fuels (Agee et al. 2000).

There is a direct correlation between the severity of a fire and the fire's impacts to wildlife (FRAP Website). Most researchers feel that fire-related wildlife mortality is minimal, but the fire's impact on habitat, which affects food, cover, and microclimate, has more significant effects on wildlife. Some species of wildlife that are dependant on dense forest habitat may have to relocate after a fire; however, other species may move in after the fire if they prefer recently disturbed or open habitats. Most species of mammals and breeding birds will remain in an area after a fire (Kilgore 1976).

Fuel load management has benefits in addition to fire control. Reduced damage and loss of timber resources are evident from areas treated for fuel load. A study conducted in 1979 found mortality of 100 percent in untreated stands compared to 17 percent for treated stands. Firefighter safety is increased with fuel management due to the removal of excess fuel and ladder fuels, which are components to high hazard fires. Prescribed burns used as fuel treatments also provide good training opportunities for firefighters without the impending need for suppression (FRAP Website).

Areas with natural fire cycles of short interval and low-intensity fires are likely to have significant ecosystem benefits from fuel treatments conducted by prescribed burning to emulate natural fire effects. Without natural fires, the natural succession of the forest produces higher stocking of vegetation and shifts in structure. This environment decreases biodiversity and increases vegetation mortality from competition, insects, and pathogens. Returning fire to the ecosystem as a restoration practice and fuel load treatment can reverse this trend.

It is difficult to evaluate the cost-effectiveness or financial benefits to using fuel load management treatments due to poor data or speculation of costs and losses. However, several models have been developed that can predict the costs and losses of wildfires using expert knowledge and varying inputs for conditions such as topography, weather, fuel load, wind speeds, etc. A study conducted in 1991 found that prescribed burning reduced costs and losses by 26 percent. According to Omi et al. (1997), the costs of USFS suppression forces from 1985 to 1993 were four times higher than planned prescribed fires ($18.4 vs. $4.27 million), excluding Alaska. In each USFS region, the cost per acre of suppression was 10-60 times the cost of an average prescribed fire.

6.0 FUEL LOAD MANAGEMENT POLICIES AND PLANS

The primary fire management programs in and immediately surrounding the study area are managed by the USFS, CDF, and DPR. BLM, DFG, Butte County, and the City of Oroville also have lands within the vicinity and fire management or suppression policies. Table 6.0-1 lists the policies and plans that have been reviewed for SP-L5.

Table 6.0-1. Relevant fire management policies and plans in the study area.

Agency	Document Title	Date
FEDERAL		
Department of Agriculture	Healthy Forest Initiative	2002
USFS	Sierra Nevada Forest Plan Amendment, Record of Decision	2001
USFS	Plumas and Lassen National Forests, Proposed Administrative Study	2002
BLM	Redding Resource Management Plan	1993
STATE		
CDF & SBF	The California Fire Plan	1996
CDF	Butte Unit Fire Management Plan	2002
DPR	Wildfire Management Planning: Guidelines and Policy	2002
DPR	Loafer Creek Prescribed Fire Management Plan, Lake Oroville State Recreation Area	1999
DFG	Oroville Wildlife Management Area Management Plan	1978
LOCAL		
City of Oroville	General Plan	1995
Butte County	General Plan	1996

Source: Compiled by EDAW 2003

6.1 HEALTHY FOREST INITIATIVE

In December 2002, the Bush Administration announced a series of steps to reduce the threat of catastrophic wildfires and improve the health of the forests. The Healthy Forests Initiative will implement core components of the National Fire Plan's 10-year Comprehensive Strategy and Implementation Plan. The National Fire Plan, which was adopted in 2002 by federal agencies and western governors in collaboration with county commissioners, State foresters, and tribal officials, calls for more active forest and rangeland management. It establishes a framework for protecting communities and the environment through local collaboration on thinning, planned burns, and forest restoration projects. The intent of the initiative is to streamline the process for approving projects to reduce the threat of wildfires and insect infestations. The new procedures are intended to ensure that environmental and public reviews are conducted in the most efficient and effective way possible.

6.2 U.S. FOREST SERVICE, PLUMAS AND LASSEN NATIONAL FORESTS PROPOSED ADMINISTRATIVE STUDY, 2002

The USFS manual states that "the objective of fire suppression is to safely suppress wildfires at a minimum cost consistent with land and resource management objectives and fire management direction as stated in fire management action plans" (USFS 1994). USFS lands in the study area are part of the Plumas and Lassen National Forests and are managed under the *Plumas National Forest Land and Resource Management Plan* (USFS 1988). This plan establishes a suppression-only policy for wildfire management. In addition, management of these lands is influenced by the more recent *Sierra Nevada Forest Plan Amendment* (SNFPA) (USFS 2001), which was developed largely to improve forest management to include conservation strategies for old-growth forest and associated species (such as the California spotted owl).

The SNFPA directed that a proposed study be carried out to address significant scientific uncertainties that are confounding management decisions. As a result, the Plumas and Lassen National Forests are proposing to conduct an administrative study on fire and fuels management, landscape dynamics, and fish and wildlife resources (USFS 2002). The study is needed to resolve persistent questions about the effects of vegetation management actions on wildland fire behavior, silvicultural goals, landscape dynamics, and viability of species dependent on old forests. The purpose of the study is to gather scientific data to resolve key ecological and forest management questions to make informed future management decisions.

An administrative study was proposed in December 2002 but was cancelled on April 25, 2003 because of the need to configure a different study proposal that accommodates the implementation of the mandating legislation (Herger-Feinstein Quincy Library Group Forest Recovery Act) and the National Fire Plan while simultaneously addressing concerns with the scientific design of the originally proposed study. However, the cancelled study design is presented below as a guide to understanding some of the potential treatment options.

The proposed study area included western portions of the Plumas and Lassen National Forests. The area included approximately 1.13 million acres, divided into 11 treatment units based on watersheds. Each treatment unit was assigned one of three treatment regimes (Table 6.2-1). The replication of treatment regimes was designed to allow statistically valid analysis of the relative resource response to the type of forest management, but was found to be inadequate.

Table 6.2-1. Treatment regimes established in the Plumas and Lassen proposed administrative study.

Treatment Regime	Defensible Fuel Profile Zones	Group Selection	Strategically placed Area Treatment
A	Treatment to comply with SNFPA direction	None	Relatively smaller-sized units; treatments to comply with SNFPA direction
B	Treatments include variance from SNFPA diameter; canopy cover, and disturbance-extent limits	5.7% of adjusted land base per 10-year interval	Relatively smaller-sized units; treatments include variance from SNFPA diameter, canopy cover, and disturbance-extent limits
C	Treatments include variance from SNFPA diameter; canopy cover, and disturbance-extent limits	11.4% of adjusted land base per 20-year interval	Relatively larger-sized units; treatments include variance from SNFPA diameter, canopy cover, and disturbance-extent limits
Target Timing	1 to 4 years	1 to 4 years	5 to 7 years

Source: USFS 2002

Although the proposed administrative study would have covered a large portion of the land within the Plumas and Lassen National Forests, other National Forest lands may be managed for fuel load reduction. Primary techniques that the Plumas National Forest uses are thinning-from-below, mastication, and underburning; in some areas, goats may be also be used. However, no fuel load reduction activities are planned in the study area due to the steepness and inaccessibility of the terrain (pers. comm., Case, 2003).

6.3 BUREAU OF LAND MANAGEMENT

The study area includes land managed by the Redding Resource Area of the BLM. BLM and National Forests lands have similar fire policies (Husari and McKelvey 1996). BLM policy states that "wildfire losses will be held at a minimum through timely and effective suppression action consistent with the values at risk." However, the Redding Field Office does not have fire suppression responsibilities for the public land it manages. Fire suppression responsibilities are provided by CDF through a Cooperative Protection Agreement authorizing CDF to protect public lands from wildland fire.

Special Management Areas (e.g., wilderness, wild and scenic rivers, areas of critical environmental concern [ACEC], natural resource areas, and archeological sites) require certain suppression restrictions to normal fire fighting tactical techniques, such as no use of tractors or heavy equipment. These areas are identified in a local Operation Plan, which was developed as a working document between State and federal agencies to clarify which local CDF fire station is responsible for certain public land and to identify local protection boundaries. One special management area is located within CDF's Butte Unit, the Forks of Butte Creek ACEC. This area is 8 to 13 miles northeast of

Oroville Facilities Chico from Portuguese Point down to Helltown, along Butte Creek, and is not in the study area.

BLM has scattered properties throughout the project vicinity. Managing isolated properties is very difficult, especially since there are currently only two staff people assigned to address fuel load and fire issues in five counties in northern California. The Redding Resource Management Plan (1993) recognizes the challenge of managing isolated parcels and has identified many for transfer to an interested entity in exchange for other lands. However, BLM does try to address fuel load issues on lands that are adjacent to other agency lands and where treatments are planned. For example, the BLM is currently working with the Plumas National Forest in the Magalia and Paradise areas to create shade fuelbreaks adjacent to residences and other properties (pers. comm., Herzog, 2003).

6.4 CALIFORNIA DEPARTMENT OF FORESTRY AND FIRE PROTECTION AND STATE BOARD OF FORESTRY, THE CALIFORNIA FIRE PLAN, 1996

In 1996, the State Board of Forestry (SBF) and CDF adopted a comprehensive update of the fire plan for wildland fire protection in California. The California Fire Plan establishes a Statewide framework to identify areas of concentrated assets and high risk, to create a more efficient fire protection system, to provide for citizen involvement, to identify prefire management needs, to encourage an integrated intergovernmental approach, and to enable policy-makers and the public to focus on effective ways to reduce future costs and losses from wildfires.

The overall goal of the California Fire Plan is to reduce total costs and losses from wildland fire in California by protecting assets at risk through focused prefire management prescriptions and increase initial attack success. The strategic objectives are: (1) to create wildfire protection zones that reduce the risks to citizens and firefighters, (2) to assess all wildlands, not just the State responsibility areas, (3) to identify and analyze key policy issues and develop recommendations for changes in public policy, (4) to have strong fiscal policy focus and monitor the wildland fire protection system in fiscal terms, and (5) to translate the analyses into public policies.

The California Fire Plan applies to the project indirectly because the information within the plan is refined at the Ranger Unit level. Each unit develops a specific fire management plan that includes details broken down by battalions that are contained with the unit. The Oroville Facilities located within Battalions Three, Five, and Six of the Butte Unit.

6.5 CALIFORNIA DEPARTMENT OF FORESTRY AND FIRE PROTECTION BUTTE UNIT, THE BUTTE UNIT FIRE MANAGEMENT PLAN, 2002

The Butte Unit Fire Management Plan (Fire Management Plan) documents the assessment of fire management within the Butte Unit and identifies strategic areas for prefire planning and fuel treatment to reduce destruction and costs associated with wildfire. The plan systematically assesses the existing level of wildland fire protection service, identifies high-risk and high-value areas where potential exists for costly and damaging wildfires, ranks these areas in terms of priority needs, and prescribes methods to reduce future costs and losses. The Fire Management Plan has four components: (1) level of service, (2) assets at risk, (3) hazardous fuels, and (4) historical fire weather.

To reduce the destruction and costs associated with wildfire, the Fire Management Plan aims to protect assets at risk through focused prefire management prescriptions, and in turn to improve initial attack success. The Fire Management Plan identifies five strategic objectives:

(1) Wildfire Protection Zones – Create wildfire protection zones that reduce the risk to citizens and firefighters.

(2) Initial Attack Success – Assess the initial attack fire suppression success of wildland fires on lands of similar vegetation type. This is measured in terms of percentage of fires that are successfully controlled before unacceptable costs and losses occur. The analysis can be used to determine the level of success of both the department and the unit.

(3) Assets Protected – Use a methodology for defining and protecting assets and determining their degree of risk from wildfire. The assets at risk addressed in the plan are life safety (citizen and firefighter), watersheds and water quality, timber, wildlife and wildlife habitat, rural communities, unique areas (scenic, cultural, and historic), recreation, range, property in the form of structures, and air quality.

(4) Fire Management Prescriptions – Develop fire management prescriptions that focus on alternative means of protecting assets at risk. Prescriptions may include a combination of fuel modification, ignition management, fire-wise planning and education, and predevelopment planning. Specific activities include (but are not limited to) land use planning and associated regulations, educational programs and public information, department infrastructure including fire stations and water systems, fuels management, and forest health. Prefire management prescriptions will also identify those who will benefit from such work and consequently those who should share in the project costs.

(5) Fiscal Framework – Use the fiscal framework being developed by the SBF and CDF for assessing and monitoring annual and long-term changes in California's wildland fire protection systems. Incorporate prefire workload analyses in an attempt to provide relevant data to guide in the development of the fiscal framework and public policy.

The study area is primarily located within the service area of Battalion Six, although portions of the study area are also located within the service areas of Battalions Three and Five. The primary causes of fires in the study area are arson, debris burning, equipment use, and children playing with fire. Fire prevention programs and some of the objectives in Battalions Three, Five, and Six include educating the community on fire prevention, conducting fire inspections throughout the battalions, establishing local fire safety councils, reducing arson fires and illegal debris burning, improving vegetation management programs, and improving accuracy of cause determination in preliminary fire investigations.

6.6 DEPARTMENT OF PARKS AND RECREATION, WILDFIRE MANAGEMENT AND PLANNING, GUIDELINES AND POLICY, 2002

Any DPR park unit that contains vegetation that would sustain a wildland fire is required by the Departmental Operations Manual to prepare a wildfire management plan. Only half of the established park units would require a wildfire management plan, based on the vegetation composition and structure. The guidelines provide a sample outline of a wildfire management plan and details of what should be included (DPR 2002).

The guidelines suggest that a wildfire management plan be separated into three main sections: (1) *Before the Fire*, (2) *During the Fire*, and (3) *After the Fire*. These sections describe the activities that are to occur during each phase of the fire. All three portions of the guidelines provide background information on how to prepare that section of the plan and the organization of department representatives. All fire fighting organizations in California operate under the Incident Command System (ICS), which is the formal administrative structure implemented to organize the complex workforce of fire fighting. During a fire, DPR's role in the ICS structure will depend on the specific conditions presented by the fire.

The guidelines suggest that the *Before the Fire* portion of the plan include any background information or preparation for fires. Specific topics suggested include wildfire potential, prefire preparation, alert levels (low, moderate, extreme), fuel management, training, fire drill, fire equipment and supplies, communications, roads, planning meetings, and a fire management compartment map.

The *During the Fire* portion should discuss fire protection priorities, fire safety, emergency evacuation plans, and modified fire suppression. Modified fire suppression includes such techniques as burnouts from natural or artificial breaks in the fuel continuity, water drops, wet lines, foam lines, and hand lines instead of dozer lines. The natural and cultural resources that DPR is mandated to protect may be at risk by some common fire suppression techniques, which disturb the soil, such as dozer lines, and may permanently destroy cultural or natural resources (DPR 2002).

The guidelines also include a section for *After the Fire,* which would cover fire history documentation, post fire resource damage mitigation, volunteer work, and pest exclusion (DPR 2002). In addition, numerous appendices are included in the guidelines, which provide specific regulations and techniques for fire protection and suppression as well as fuel load management.

6.7 DEPARTMENT OF PARKS AND RECREATION, LOAFER CREEK PRESCRIBED FIRE MANAGEMENT PLAN, 1999

The Loafer Creek Prescribed Fire Management Plan was prepared in 1999, prior to the DPR Guidelines established in 2002 described above. Loafer Creek Campground is located on the south side of Lake Oroville. An area description is provided that includes basic information on the physical and natural resources of the area. Quantified data are provided for precipitation, climate, and temperature. Natural resources including vegetation, wildlife, cultural, and aesthetic resources are also summarized in the area description. Recreation, fire history, and fuel characteristics are discussed.

Program objectives are defined as reducing the hazard of wildfire in developed areas while perpetuating the natural processes of plant succession in the intervening wildlands (DPR 1999). Objectives outlined in the plan include vegetation management within campgrounds that maintains visual screening, thinning on roadways and trails, and prescribed fires to reduce fuel load in the brushy understory. The DPR District Resource Ecologist is identified as the Prescribed Fire Manager, the Maintenance Supervisor is in charge of thinning and field crews, and the Burn Boss reviews and approves burn plans prepared by the Prescribed Fire Manager.

Constraints and mitigation for the effects of fire and fuel treatments are described, including: air quality and smoke management, wildlife, vegetation, cultural resources, soils, and geologically sensitive areas. Air quality is affected by burn smoke; therefore, burns are planned to occur in the late spring when allotments for generation of smoke are greater. Wildlife such as ground dwellers and raptors and vegetation such as the Butte County fritillary flower can be affected by fires. Small compartment areas are burned, leaving adjacent areas for escape for wildlife. Mature plants that die back to bulbs in the summer are generally not affected by fires in late spring or early fall. Known cultural resources would be avoided by fire lines, and roads and trails would be designed to minimize soil erosion and have adequate drainage structures.

A monitoring program is outlined in the Loafer Creek Prescribed Fire Management Plan, which includes ongoing research to test the efficiency and effectiveness of fuel load management techniques. Fire behavior such as the type of fire, rate of spread, and other factors will be recorded in relation to the external conditions (e.g., wind and moisture). Short- and long-term effects will be documented over time. Scorch marks and leaf browning are used for identifying short-term effects, and annual photography is used to show the change in vegetative structure over the long term.

A burning program is defined, which identifies the Loafer Creek Subunit as the management compartment of the vegetative management plan. The Subunit is divided into several burn units and exclusion zones using existing roads and trails. The priorities of the plan are outlined, including the enhancement of safety for visitors. Prescriptions must be documented for each burn and developed by the Prescribed Fire Manager. In addition, fire line construction standards, patrol, and escaped fire suppression are described as part of the burn program.

6.8 DEPARTMENT OF FISH AND GAME

In 1968, 5,500 acres were transferred from DWR to DFG to create the Oroville Wildlife Area (OWA). In 1978, DFG developed the Oroville Wildlife Area Management Plan. The purpose of the management plan was to provide for the preservation and enhancement of the OWA and for the reasonable use and enjoyment by the public. The management plan also states that destructive uses and activities incompatible with wildlife and fisheries objectives that were present at the time the management plan was written will be eliminated through enforcement of existing regulations or development of additional regulations if necessary.

Fuel load issues were not addressed specifically in the management plan. However, fires frequently start in the OWA, primarily due to accidental fires starting from recreational activities such as camping or the shooting range, or arson (pers. comm., Atkinson, 2003). OWA staff are largely involved in maintenance activities and are unable to dedicate time to wildlife habitat enhancement, vegetation restoration, or fuel load reduction projects (pers. comm., Atkinson, 2003).

6.9 BUTTE COUNTY

The Butte County General Plan (1996) identifies the threat of wildland fire to forests, wildlife, watersheds, and scenic resources along with the destruction of homes and other property. There may also be injury or loss of life. Secondary impacts include a reduction in the value of land and the further degradation of natural resources.

The general plan (General Section 9) states:

> Most of the valley fires in Butte County have been grass fires near the more populated areas of Chico, Durham, Richvale, Biggs, Gridley, and Oroville, and along the main roads connecting these communities. Although there have been fewer fires in the foothill and mountain areas than in the valley, there have been a disproportionately higher number of fires per unit of population in the foothills and mountains. This condition is probably due to the more hazardous natural combination of dense vegetation, dry weather, and steep topography which encourages rapid fire spread. (The critical factor contributing to fire spread and intensity is the density and distribution of vegetative fuel, especially brush and forests.) The number of fire incidences in the foothill and mountain area can be expected to increase along with an increase in recreational activities and residential uses. A significant hazard to life and structures from wildland fire does not exist until a wildland area is developed and occupied only does the introduction of human activity into wildlands increase fire occurrences, it also increases the demand for rapid response and control of those fires.

The general plan also states that subdivisions, land divisions, and use permits are subject to review and approval by the County Fire Department for conformance to fire safety standards. New buildings must conform to the Uniform Building Code (UBC) requirements for fire protection systems and minimum fire resistance of materials. The county has not adopted the Uniform Fire Code, a complementary code to the UBC. The Uniform Fire Code regulates the maintenance of property and certain dangerous and hazardous activities.

Policies based on findings in the general plan relating to fire hazards are as follows:

(1) Make protection from fire hazards a consideration in all planning, regulatory, and capital improvement programs, with special concern for areas of high and extreme fire hazard.

(2) Encourage adequate fire protection services in all areas of population growth and high recreation use.

(3) Use fuelbreaks along the edge of developing areas in high and extreme fire hazard areas.

(4) Attempt to upgrade fire service where economically feasible.

(5) Carefully evaluate the effect of development on water supplies.

(6) Determine the level of water supplies necessary for new development for fire protection purposes.

(7) Ensure that road access for new development is adequate for fire protection purposes.

(8) Require or promote the easy identification of streets and developed properties.

(9) Regulate as necessary those activities and uses with a high fire potential except uses regulated by the Forest Practices Act.

(10) Regulate use of certain building materials in areas of higher-than-average fire hazard.

(11) Require water connection to swimming pools for purposes of fighting fires.

6.10 CITY OF OROVILLE

The City of Oroville has a city ordinance that establishes a benchmark date (June 15 of each year) for weed abatement or hazardous material reduction. This ordinance applies to vacant lots and alleys within the city boundaries and requires that the flammable vegetation be removed to mineral soil or mowed to 4 inches. Other properties must properly maintain and irrigate landscaping around structures. For large parcels (greater than 1 acre), livestock grazing is encouraged to reduce fuels. The City also works with CDF to coordinate fire prevention and safety education (such as FireWise Community programs) within the community (pers. comm., Pittman, 2003).

7.0 SUGGESTED FUEL LOAD REDUCTION MEASURES

This section presents some general suggestions for fuel load reduction within the study area. Additional data useful to developing recommendations are discussed, including past fire ignitions and preliminary vegetation mapping. Suggestions were developed based on the review of techniques and strategies provided in Section 5 and review of the programs and policies currently used by land management agencies presented in Section 6.

7.1 FIRE IGNITIONS DATA FOR THE STUDY AREA

CDF has kept records of all fire ignitions in Butte County, regardless of size, since 1990. The location of the ignitions are not recorded precisely but are plotted as the center of quarter sections. The estimated locations are within approximately 160 acres of the true location. Because the centers of some quarter sections occur within water bodies, as a result of the estimated mapping, it may appear that some ignitions are within water bodies.

The frequency of ignitions for each quarter section was calculated and the data classified into ranges. Figure 7.1-1 shows the frequency of ignitions in the project region. Because almost every quarter section experienced at least one ignition since 1990, the sections containing between one and six ignitions are not displayed on the figure. These data were excluded to highlight the areas with more frequent (greater than seven) ignitions. The most frequent ignitions have occurred in the urbanized areas around Oroville, Thermalito, and other communities; the Clay Pit State Vehicular Recreation Area; and along roadways. Although not all of these areas are within the study area, fires that start in the region have the potential to move into the study area.

Within the study area, the cause of fire ignitions was examined (Table 7.1-1). The most common cause (24 percent) of ignitions was use of equipment. Unidentified and miscellaneous causes each made up approximately 15 percent of all ignitions. Arson was the fourth most frequent (14 percent) cause of ignitions.

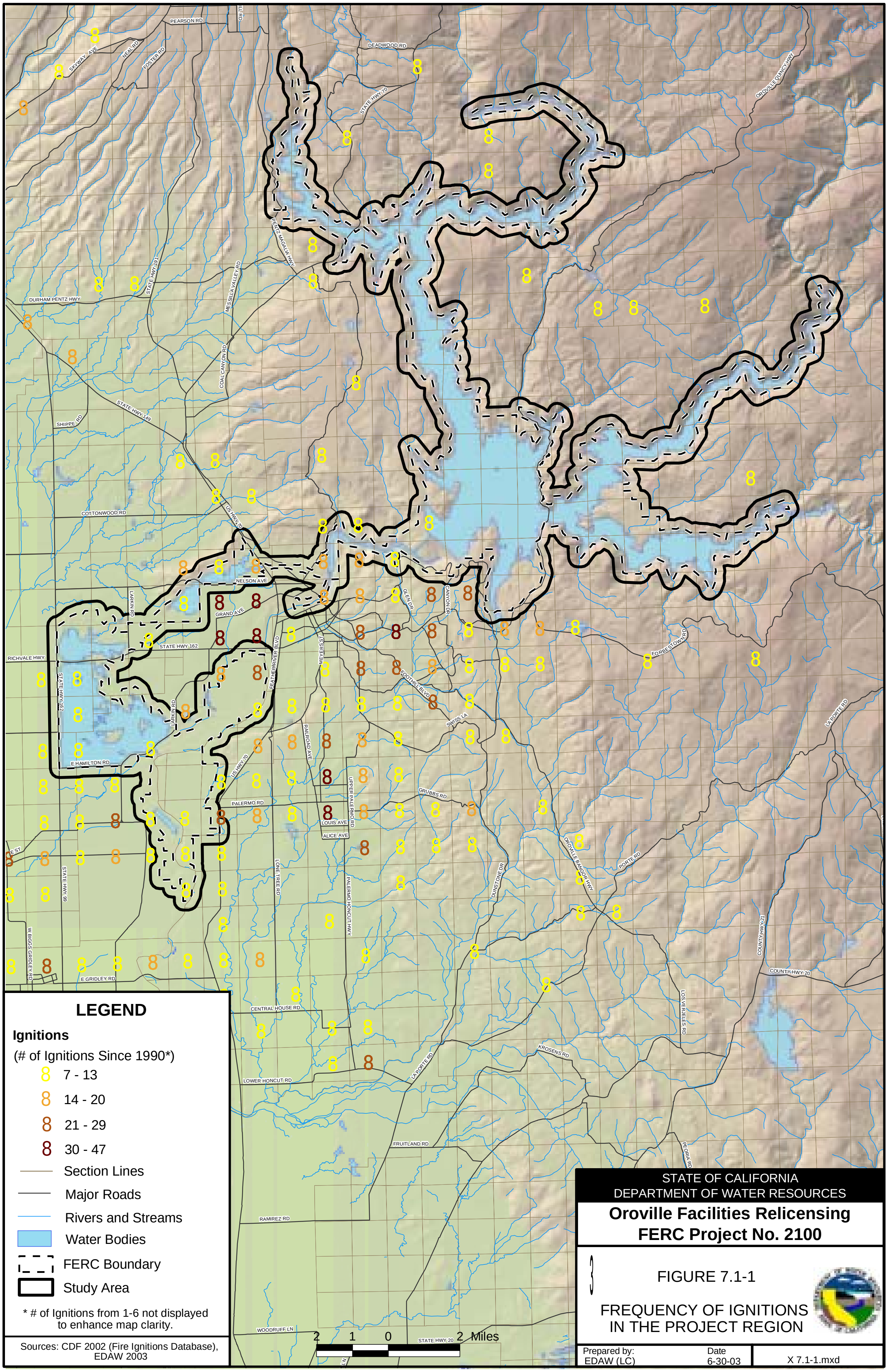
7.2 VEGETATION CLASSIFICATION WITHIN THE STUDY AREA

The type of vegetation and its density contribute to the level of fuel load hazard and are important to determining appropriate reduction techniques. Although CDF's fuel hazard model considered vegetation type and other fuel variables, the analysis was conducted at a very coarse scale (450-acre blocks). Knowledge of vegetation types at a more refined scale is important in determining conditions for a specific location and identifying appropriate actions. Although this level of analysis is not within the scope of this study, data are being gathered by other work groups that may facilitate detailed analysis in the future.

Table 7.1-1. Frequency and cause of fire ignitions within the study area, since 1990.

Cause of Ignition	Frequency	Percent
Use of Equipment	96	24.2
Unidentified	63	15.9
Miscellaneous	61	15.4
Arson	55	13.9
Debris or garbage burning	28	7.1
Vehicle	27	6.8
Playing with fire	18	4.5
Powerline	15	3.8
Smoking	13	3.3
Lightning	8	2.0
Campfire	8	2.0
Railroad	5	1.3
Total	**397**	**100%**

Source: CDF 2002d


PEARSON RD
DEADWOOD RD
SKYWAY AVE
NEAL RD
FOSTER RD
STATE HWY 70
OROVILLE QUINCY HWY
PENTZ MAGALIA HWY
DURHAM PENTZ HWY
STATE HWY 191
MESSILLA VALLEY RD
COAL CANYON RD
STATE HWY 149
SHIPPE RD
COTTONWOOD RD
US HWY 70
NELSON AVE
GRAND AVE
LARKIN RD
STATE HWY 162
RICHVALE HWY
FEATHER RIVER BLVD
MEYERS ST
GLEN DR
CANYON DR
FORBESTOWN RD
FOOTHILL BLVD
SWISS LA
LA PORTE RD
E HAMILTON RD
RAILROAD AVE
UPPER PALERMO RD
GRUBBS RD
PALERMO RD
LOUIS AVE
ALICE AVE
STATE HWY 99
LONE TREE RD
PALERMO HONCUT HWY
DUNSTONE DR
OROVILLE BANGOR HWY
PORTE RD
W BIGGS GRIDLEY RD
E GRIDLEY RD
COUNTY HWY 21
COUNTY HWY 20
CENTRAL HOUSE RD
LOS VERJELES RD
KROSENS RD
LOWER HONCUT RD
FRUITLAND RD
PEORIA RD
RAMIREZ RD
WOODRUFF LN
STATE HWY 20
LEGEND
Ignitions
(# of Ignitions Since 1990*)
7 - 13
14 - 20
21 - 29
30 - 47
Section Lines
Major Roads
Rivers and Streams
Water Bodies
FERC Boundary
Study Area
* # of Ignitions from 1-6 not displayed to enhance map clarity.
Sources: CDF 2002 (Fire Ignitions Database), EDAW 2003
2 1 0 2 Miles
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
Oroville Facilities Relicensing
FERC Project No. 2100
FIGURE 7.1-1
FREQUENCY OF IGNITIONS IN THE PROJECT REGION
Prepared by: EDAW (LC)
Date 6-30-03
X 7.1-1.mxd

Vegetation types and canopy cover classifications were mapped in the study area by DWR resource ecologists as part of the environmental studies conducted for the project. Vegetation was mapped approximately 1 mile beyond the edge of the FERC boundary using aerial photos and were ground-truthed. The classification system for vegetation types and canopy cover was based on the California Wildlife Habitat Relationship system (Mayer and Laudenslayer 1988). The minimum size of polygons mapped was approximately 0.5 acre. These data should be considered preliminary; the classification system may be slightly modified as the data are analyzed (pers. comm., Kuenster, 2003).

The most abundant vegetation types are summarized in the tables below by four general areas (see Figure 4.2-2) within the study area (Tables 7.2-1 through 7.2-4). Because mapping was based on land cover, the reservoir and other water bodies are included in the total area. In general, most of the study area is characterized by woodland and shrub communities, composed of different dominant species. Grasslands compose only a very small portion of the vegetation in the study area (less than 1 percent of total area) and are found in the Lake Oroville and Oroville Wildlife Area portions of the study area.

Table 7.2-1. Major vegetation types and canopy cover for the Lake Oroville portion of the study area.

Land Cover Type	Canopy Cover	Acres	Percent of Total Area
Lake Oroville	--	15,159	33%
Foothill pine/mixed oak woodland/chaparral	60-100%	5,992	13%
Foothill pine/mixed oak woodland	60-100%	3,664	8%
Mixed oak woodland	60-100%	3,064	7%
Mixed oak woodland/chaparral	60-100%	2,657	6%
Other types each contribute less than 3% to total	varies	15,042	32%
Total	**varies**	**45,578**	**100%**

Source: DWR 2003

Table 7.2-2. Major vegetation types and canopy cover for the Diversion Pool and Thermalito Forebay portion of the study area.

Land Cover Type	Canopy Cover	Acres	Percent of Total Area
Lake Oroville	--	2,248	27%
Foothill pine/mixed oak woodland/chaparral	25-39%	886	11%
Short forbland	--	783	10%
Blue oak/foothill pine woodland	25-39%	610	7%
Black willow/blackberry scrub	40-59%	597	7%
Mixed chaparral	60-100%	450	6%
Mixed willow riparian forest	25-39%	233	3%
Mixed oak woodland chaparral	60-100%	205	3%
Other types each contribute less than 2% to total	varies	2,170	26%
Total	**varies**	**8,182**	**100%**

Source: DWR 2003

Table 7.2-3. Major vegetation types and canopy cover for the Thermalito Afterbay portion of the study area.

Land Cover Type	Canopy Cover	Acres	Percent of Total Area
Blackberry/willow scrub	40-59%	3,110	40%
Open water	--	2,147	27%
Blue oak woodland	40-59%	828	11%
Blue oak/foothill pine chaparral	25-39%	355	5%
Mixed willow scrub	10-24%	264	3%
Blue oak woodland	25-39%	240	3%
Cottonwood riparian forest	60-100%	201	3%
Other types each contribute less than 2% to total	varies	679	8%
Total	**varies**	**7,824**	**100%**

Source: DWR 2003

Table 7.2-4. Major vegetation types and canopy cover for the Oroville Wildlife Area portion of the study area.

Land Cover Type	Canopy Cover	Acres	Percent of Total Area
Deciduous orchard	--	861	10%
Cottonwood riparian forest	40-59%	841	9%
Gravel tailings	--	790	9%
Cottonwood riparian forest	60-100%	760	8%
Cottonwood riparian forest	25-39%	735	8%
Disturbed	--	529	6%
Water primrose	--	418	5%
Riverine	--	407	4%
Pond	--	382	4%
Urban	--	327	4%
Disturbed grassland	--	285	3%
Annual grassland	--	282	3%
Residential	--	263	3%
Valley mixed riparian forest	60-100%	252	3%
Other types each contribute less than 2% to total	varies	1,885	21%
Total	**varies**	**9,017**	**100%**

Source: DWR 2003

7.3 SUGGESTED FUEL LOAD REDUCTION MEASURES

Based on the information gathered in the previous sections on fuel load conditions in the study area, fuel load reduction techniques, and fuel load management policy and plans, some general fuel load reduction measures are suggested below. These suggestions are not intended to be prescriptions for specific areas, but do provide a general framework for developing such projects in the future. Specific strategies for pre-fire management projects should be developed in close coordination with other agencies and the local communities (CDF 2002a). Table 7.3-1 identifies websites of organizations involved with fire management issues nationally, statewide, and locally.

Because of the high value of life and property and potential for high fuel loading, the interfaces between wildlands and urban areas are at significant risk of losses due to fire (SNEP 1996). The interface zone around communities should be protected by creating fuelbreaks, such as community defense zones or shaded fuelbreaks. In addition, community members should be educated about fire danger and preventative measures. Some communities have established Fire Safe Councils; these efforts should be encouraged and Fire Safe Councils in other communities should be promoted. The mission of Fire Safe Councils is to use the combined expertise, resources, and distribution channels of its members to preserve California's natural and manmade resources by mobilizing all Californians to make their homes, neighborhoods, and communities fire safe (Fire Safe Council Website). Community members should be encouraged to create defensible space around their homes and follow fire safety guidelines for inside and outside of homes. Information regarding how to create fire safe communities is readily available on the internet through the Fire Safe Council and CDF websites listed below. Properties in the wildland-urban interface also should be inspected for hazardous fuel conditions to ensure compliance with city, county, and State ordinances.

Table 7.3-1. Fire management organizations and websites.

Organization	Program	Website
Fire Safe Council	National	http://www.firesafecouncil.org/
Butte County Fire Safe Council	Local	http://www.firesafecouncil.org/
Oroville Community Association	Local	http://www.firesafecouncil.org/
California Department of Forestry and Fire Protection and State Board of Forestry	Statewide	http://www.fire.ca.gov/FireEmergencyResponse/FirePlan/FirePlan.asp
California Department of Forestry and Fire Protection	Statewide Resource Management Program	http://www.fire.ca.gov/ResourceManagement/ResourceManagement.asp
California Department of Forestry and Fire Protection	Statewide Fire and Resource Assessment Program	http://frap.cdf.ca.gov/
California Fire Alliance	Statewide Inter-agency coordination	http://www.cafirealliance.org/default.php
National Fire Plan	National	http://www.fireplan.gov/
U.S. Forest Service	National Fire and Aviation Management	http://www.fs.fed.us/fire/
Bureau of Land Management	National Office of Fire and Aviation	http://www.fire.blm.gov/

Source: Compiled by EDAW 2003

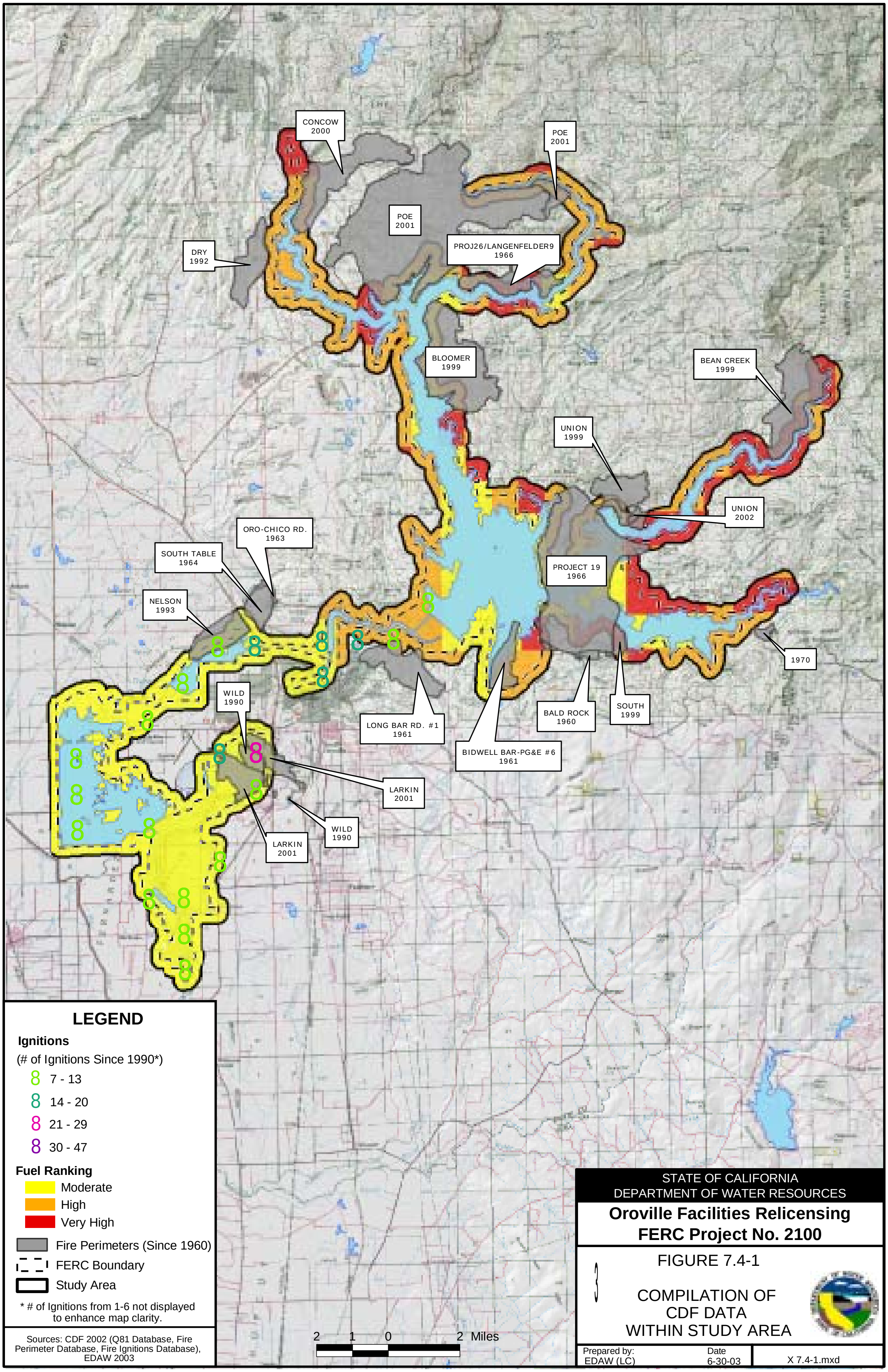
In other wooded areas, fuelbreaks or DFPZs should be created to reduce the chance of fire spreading and to provide a safe area for fire suppression efforts. Fuels should be reduced in target areas, using techniques appropriate to the site. Preferred methods generally are mastication and thinning from below, as these methods tend to be less environmentally damaging and are fairly cost-efficient compared to other methods (See Table 5.1-1). However, other techniques may be recommended for specific areas. Once fuels have been reduced, prescribed burns could be used, where feasible, to restore ecological processes.

In grassland areas, prescribed burn should be used where feasible to control weeds, to promote nutrient cycling, and to encourage growth of native species (especially in vernal pool ecosystems). If burning is not feasible, fuels could be reduced by mowing or disking. Grazing in selected areas may be a useful technique to reduce fuel load, if it is compatible with other land use policies and goals in the area.

In riparian areas, prescribed burns conducted in the early spring may be an effective method to reduce ground fuels and promote germination of herbaceous species, thus enhancing wildlife habitat (pers. comm., Atkinson, 2003). Burning in the spring, when fuels are not as dry as later in the year, allows the fire to be at a cooler temperature and protects riparian trees from scorching. Spring burning should be conducted early in the season, before most birds initiate nesting activities.

7.4 COMPILATION OF CDF DATA

CDF's fire ignitions data, fire history data, and fuel hazard rankings within the study area are displayed together in Figure 7.4-1. Only fires since 1960 (the approximate start of the Oroville Facilities' operation) are included. This map could be used to identify general areas that may warrant more detailed evaluation in the future. For example, an area where there is a high frequency of ignition, that is within an area of very high fuel hazard, and that has not burned recently may be considered a priority for developing a fuel reduction project. Identifying specific areas for fuel treatment is not part of the objectives of this study but would be part of developing a fire management plan.


CONCOW
2000
POE
2001
POE
2001
PROJ26/LANGENFELDER9
1966
DRY
1992
BLOOMER
1999
BEAN CREEK
1999
UNION
1999
UNION
2002
ORO-CHICO RD.
1963
SOUTH TABLE
1964
NELSON
1993
PROJECT 19
1966
1970
WILD
1990
LONG BAR RD. #1
1961
BIDWELL BAR-PG&E #6
1961
BALD ROCK
1960
SOUTH
1999
LARKIN
2001
WILD
1990
LARKIN
2001
LEGEND
Ignitions
(# of Ignitions Since 1990*)
7 - 13
14 - 20
21 - 29
30 - 47
Fuel Ranking
Moderate
High
Very High
Fire Perimeters (Since 1960)
FERC Boundary
Study Area
* # of Ignitions from 1-6 not displayed to enhance map clarity.
Sources: CDF 2002 (Q81 Database, Fire Perimeter Database, Fire Ignitions Database), EDAW 2003
2 1 0 2 Miles
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
Oroville Facilities Relicensing
FERC Project No. 2100
FIGURE 7.4-1
COMPILATION OF
CDF DATA
WITHIN STUDY AREA
Prepared by:
EDAW (LC)
Date
6-30-03
X 7.4-1.mxd

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